ELECTRONICS, COMPUTERS, TECHNOLOGY

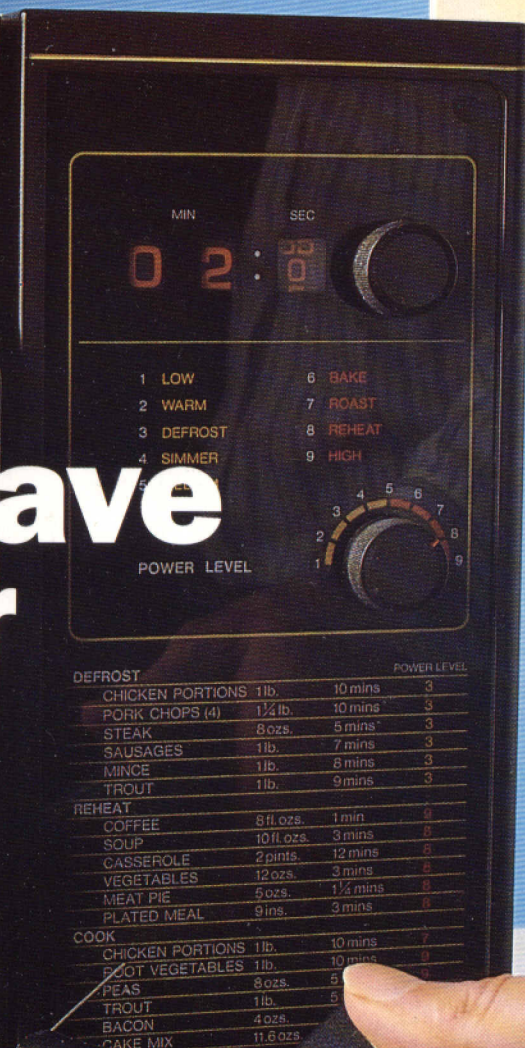## Pump Charge Devices
## Mind Trainer

## Car Battery Tester

## Hands-Free Telephones

## Low Cost Cases

# Microwave Monitor

## Use our cover PCB

**Please tell your retailer if the PCB is missing**

| MIN | SEC |
| 0 2 : 0 | |

| 1 LOW | 6 BAKE |
| 2 WARM | 7 ROAST |
| 3 DEFROST | 8 REHEAT |
| 4 SIMMER | 9 HIGH |

POWER LEVEL

| DEFROST | | | POWER LEVEL |
|---|---|---|---|
| CHICKEN PORTIONS | 1 lb. | 10 mins | 3 |
| PORK CHOPS (4) | 1¼ lb. | 10 mins | 3 |
| STEAK | 8 ozs. | 5 mins | 3 |
| SAUSAGES | 1 lb. | 7 mins | 3 |
| MINCE | 1 lb. | 8 mins | 3 |
| TROUT | 1 lb. | 9 mins | 3 |
| REHEAT | | | |
| COFFEE | 8 fl.ozs. | 1 min | 8 |
| SOUP | 10 fl.ozs. | 3 mins | 8 |
| CASSEROLE | 2 pints. | 12 mins | 8 |
| VEGETABLES | 12 ozs. | 3 mins | 8 |
| MEAT PIE | 5 ozs. | 1½ mins | 8 |
| PLATED MEAL | 9 ins. | 3 mins | 8 |
| COOK | | | |
| CHICKEN PORTIONS | 1 lb. | 10 mins | 7 |
| ROOT VEGETABLES | 1 lb. | 10 mins | 9 |
| PEAS | 8 ozs. | 5 | 9 |
| TROUT | 1 lb. | 5 | 9 |
| BACON | 4 ozs. | | |
| CAKE MIX | 11.6 ozs. | | |

Page 34

# Features & Projects

# Contents

# Regulars

# Editorial

by Paul Freeman

☎
SUBSCRIPTION
& BACK ISSUES
HOTLINE
0737 768611

The fax machine must surely be one of the success stories of the 80s and early 90s. Faxing a letter or A4 document is invariably cheaper than sending it by post and, at just over a minute for an A4 sheet, there is an enormous time saving as well. There are inevitable drawbacks, however - unsolicited faxshots wasting expensive paper, poor quality reproduction and, at least until a couple of years ago, the need for a second telephone line. Attempts have been made at higher quality repro using laser technology, but the price tag for such machines has been too high for domestic users.
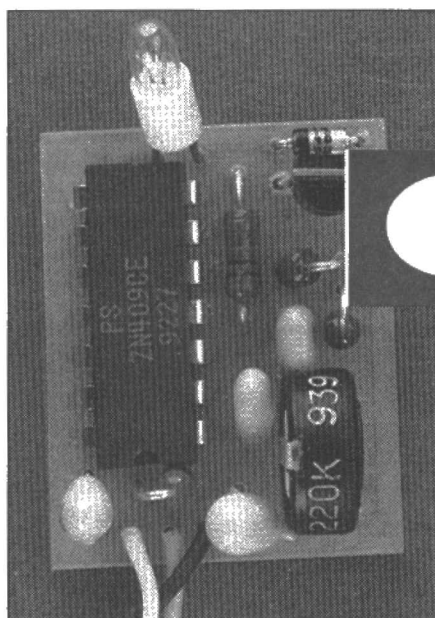
The next decade could see us still using the principle of the fax but in a different form. Computer or disk fax, with more and more potential customers, is becoming very attractive. Why bother with poor paper and repro quality when a document can appear on screen, virtually error free?

In essence, this is nothing new, for MODEMs have been sending data along telephone wires from computer to computer for a long time. It is the graphics or true pictorial representation (facsimile), reproducible on screen, that makes the difference. If both people wishing to communicate have computers, why suffer the inconsistencies of character scanning? With the added extra of pen-pads, even signatures could be added.

# OPEN CHANNEL

lthough there's little to see yet, a line has been drawn in the sand which marks the territories of the world's major computer manufacturers. Either side of this line stand some unlikely partners, gathered together for the forthcoming combat - a battle which promises to be the mother of them all.

Yeah, I know. This is all a bit corny and smacks of an unhealthy allusion to the Gulf conflict, but the war about to ensue between computer manufacturers promises to have enormous consequences. And it caught your attention too, didn't it?

Before I describe the battle to come it's best to look at the current situation and consider the history leading up to it. Basically, it's all about personal computers. In terms of numbers of units made and sold, the largest computer manufacturer is IBM. In terms of computers used, IBM PCs or IBM-compatible PCs form the vast majority. In terms of
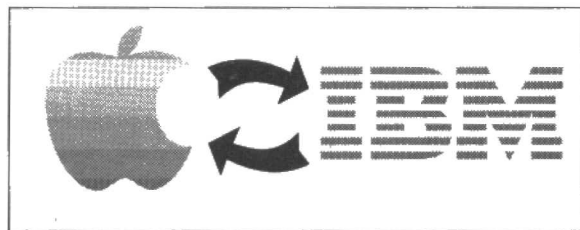


operating systems run on these PCs, one or another form of MS-DOS is the preferred choice. A new front-end, added on top of MS-DOS, is Windows - this gives the PC a graphical user interface (GUI - comprising adjustable windows in which files and programs are seen as pictorial icons, menus listing commands and features, and a mouse pointing device); and is reported to be installed on around 20% of MS-DOS machines.

The second largest computer manufacturer is Apple (which, incidentally, during 1992 sold more computers than IBM). Apple's Macintosh PC has its own operating system with a graphical user interface built-in. The Mac's GUI has been around for nine years now and, arguably, is the interface Windows tries to emulate. Third largest computer manufacturer is Compaq, producing IBM-compatible PCs.

## Firm Friends

To date, friends and foes have been fairly fixed. MS-DOS and Windows are both produced by software company Microsoft, which has grown pretty rich due to licensing deals allowing IBM-compatible manufacturers to use the systems on their PCs. Microsoft also produces applications software - word processing, database and spreadsheet among others. Interestingly, versions of most of these applications are available to run on Macintosh computers, too.

IBM-compatibles are built using Intel microprocessors based on the 80X86 series (e.g., 80286, 80386, 80486) while Apple Macintosh machines use Motorola chips based on the 68XXX range (e.g. 68020, 68030, 68040).

## Squaring Up

IBM and Apple, it seemed, were firm enemies. As a consequence Apple stood more-or-less alone. Compaq, although by no means a friend, was at least a battle partner of IBM. Microsoft pulled faces at Apple while on-the-side selling applications to Mac users. Intel and Motorola called each other names while reaping the rewards of the entrenched PC market. But times are changing and friends migrate. Recently, in an almost unthinkable move, IBM and Apple have joined forces to design the PowerPC, based on new Motorola microprocessors.

These new PowerPCs are to have an Apple-derived interface so will be easier to use than any previous IBM-compatible PC and will form the basis of an incredibly (at least by current-day standards) powerful family of PCs over the next few years. It's this development agreement which forms the biggest army so far in the computer war to come. Now Microsoft, probably sensing it's being shouldered out, has gone into partnership with Compaq and Intel to begin development of their range of next-generation PCs.

Although their plans to date appear pretty flimsy, once this army has regrouped, it's a fair bet the war won't be as one-sided as might otherwise be thought. Whatever the outcome, the munitions used up over the next couple of years will make some of the most interesting fireworks spectacles ever seen in the IT industry.

## Head-to-head

An interesting test case is about to make news. In 1981, Kodak (the film and camera people) was granted a patent which is said to form the basis of the technology of recording heads used by Sony and other manufacturers in videocassette recorders and camcorders. Kodak is to sue Sony over this, and has applied for an injunction preventing Sony products using the technology from being sold in the United States. This might be just the tip of the iceberg, of course.

If Kodak wins its case, all other videocassette and camcorder manufacturers using the technology will face the same litigation. It's hard to imagine the effect of a successful action by Kodak. Either Sony and all the other manufacturers will be forced to pay Kodak for the rights to use the technology, or they will simply not be able to sell products which feature it.

Presumably, these videocassette and camcorder manufacturers have used the technology without being aware of its origin. In this case, payments to Kodak, although healthy, will be only a proportional part of the profits made from selling the products in the first place. However, if Kodak can prove wilful infringement on the manufacturers' part, damages could well be significant. So, the next time you get out the camcorder and video the kids breaking the next-door neighbour's patio window, just remember who the camcorder actually belongs to!

**Keith Brindley**

## STUDENTS HOLD KEYS TO THE FUTURE



**P**ictured right are the three winners of the 1993 Young Electronic Designer Awards with co-sponsors Ken Sanders, Managing Director of Texas Instruments Ltd (right) and Robert Johnston, Personnel Director of Mercury Communications Ltd. (left).

Senior winner, Philip Pegden (18, centre) of Tonbridge School, designed a computerised quadraphonic sound effects system for theatres. Intermediate winner Nicola Hay (second left) of Woldingham School in Surrey achieved her success with an electronic device to monitor water contamination in brake fluid, now a requirement of the MOT. Junior winner Emma Lye (second right) of Bancroft's School in Essex won her prize with an electronic elbow, which tests the temperature of a baby's bath water.

Nicola Hay also won 'The Texas Instruments Prize' for the most commercially viable project, while Richard Coull of Harris Academy in Dundee won the 'Mercury Planet Award' for the project displaying the most environmentally and socially aware technology with his ioniser to cut carbon exhaust emissions from cars. The awards, organised by the YEDA Trust, were presented by HRH The Duke of York at the Science Museum last month.

## LASER LINE GENERATOR
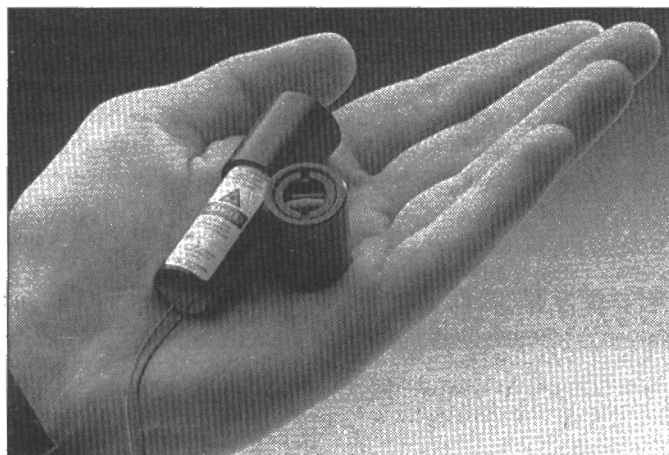


**I**matronic has introduced an industrial grade laser line generator which, when used with its range of compact laser diode modules produces a line of highly visible red laser light rather than a spot. Applications include edge detection, scanning systems, pattern recognition, medical alignment systems, light barriers, robotic control and industrial alignment and process control.

The Line Generator pushes onto the aperture of the standard range of LDM145 Compact Laser Diode Modules. The standard model, produces a fan of laser light with a fan angle of 40° (equivalent to a 0.75m line at a distance of 1m) when used together with the visible wavelength versions of the LDM145. Other fan angles are available on request.

The laser drive circuitry operates from 4 to 6V DC and draws typically 70mA. It is packaged together with the laser diode in a cylindrical aluminium housing, designed for mounting in any environment or instrument.

For further info contact:
**Imatronic Limited**
**Tel: (0635) 550477**

## SKYPHONE INTRODUCES FIRST WORLDWIDE AIRLINE FAX SERVICE

**T**he world's first global airborne fax service has been launched by Skyphone, a consortium comprising BT, Singapore Telecom and Norwegian Telecom. The new service complements Skyphone's existing worldwide telephone service.

Singapore International Airlines (SIA) will be the first airline to introduce the fax service this summer on its fleet of Boeing 747s. SIA currently provides the Skyphone telephone service, while Air China also plans to offer Skyphone telephone service and fax services later this year. The launch of the fax service follows trials which have been carried out over the past six months.

To provide full coverage, the system uses three ground earth stations, Goonhilly for Atlantic Ocean coverage, Eik for the Indian Ocean and Sentosa Island for the Pacific. Developed at BT Laboratories at Martlesham, Suffolk, Skyphone has a 2.4 kbit/s transmission rate which will be upgraded to 4.8kbit/s by early 1994.

# THIRD INTERNATIONAL CONFERENCE ON ARTIFICIAL NEURAL NETWORKS

The Institution of Electrical Engineers (IEE) is the host for the Third International Conference on Artificial Neural Networks which is to be held at the Brighton Conference Centre, UK, from 25-27 May 1993.

Featuring papers from Germany, the USA, France, Hungary, Australia, China, Belgium, Brazil, Bulgaria, Italy, Denmark, Taipan, the Netherlands and the UK, the conference will provide an international overview of the latest developments in neural networks.

The three day event will open with a Keynote Address by Professor Ron Goodman, California Institute of Technology, USA. Technical sessions at the conference will focus on key areas of activity such as, neural diagnostic aids for medical applications, manufacturing plant control and robotics, condition monitoring, visual inspection systems, forecasting and neural network validation.

The conference will also include a session on recent British Government initiatives including the Department of Trade and Industry's £5.75 million Neural Networks technology transfer and awareness programme.

The Neural Computing Applications Forum, Britain's leading neural computing membership organisation, will also be explaining its role. For a provisional programme and registration form please contact:

**Conference Services**
**IEE**
**Savoy Place**
**London**
**WC2R 0BL**
**Tel: 071 344 5472**
**Fax: 071 497 3633**

# LOW COST SECURITY SYSTEM

Maplin Electronics is now marketing a comprehensive security system kit for the home or small business. The kit consists of existing stock items bundled as a single package, thereby offering a substantial saving over the total price of the individual components.

The system includes a microprocessor-based control panel, two sensitive PIR detectors, two magnetic reed switches for windows etc., plus a 112dB siren/strobe light.

The unit package consists:
1 MSS3000 Alarm Panel
1 External Bell Box
1 12V 1.2Ah Lead-Acid Rechargeable Battery
2 Compact Indoor PIR Detectors
2 Surface Reed Switches
50m 6 core Burglar Alarm Cable
Pack of Plastic 4mm Cable Clips

The kit costs £129.95 (to incl. vat).



# MULTICORE LEADS AND TAKES OUT LEAD

In a drive to safeguard the environment and health of end-users, Multicore Solders is introducing a range of cost-effective lead-free flux-cored solder wires for hand soldering operations.

Developed particularly for the electronics and electrical industries, Multicore 99C Cored Solder Wire contains 99.3% tin/0.7% copper and has already been approved to the latest specifications including BS.219 and 1509453.

Although its melting point of 227C (440F) is slightly higher than that of conventional 60/40 tin/lead solder, 99C is easily applied using standard soldering irons operating at 350-370·C (660-700F). Its electrical conductivity is said to be better than that of 60/40 tin/lead and it has equivalent strength and fatigue resistance.

99C is also described as cost effective to use, because although it costs more per reel than 60/40 tin/lead, the end user receives about 15% more length for the same weight, as 99C is not as dense. The solder can be supplied in standard rosin and no-clean low residue versions, in wire diameters down to 0.45mm (0.02in) on standard reel sizes.

For further information contact: Multicore Solders Ltd. Tel:(0442) 233233

# 1993 WEEKEND CONFERENCE FOR YOUNG ENGINEERS

'Commercial Awareness' and 'Business Skills for Young Engineers' are the themes of the 1993 Weekend Conference organised by the London Younger Members Section of the Institution of Electrical Engineers (IEE). The Annual Conference is open to young engineers (under 30 years of age) of all disciplines, and will be held from 29-31 October 1993 at the Britannia International Hotel, Canary Wharf.

Now in its twelfth year, the Conference is divided into two parts: a series of lectures by some

of the most respected individuals in the business community; and a demanding management game which gives delegates 'hands on' experience of a broad range of business issues, including marketing, finance and teamwork.
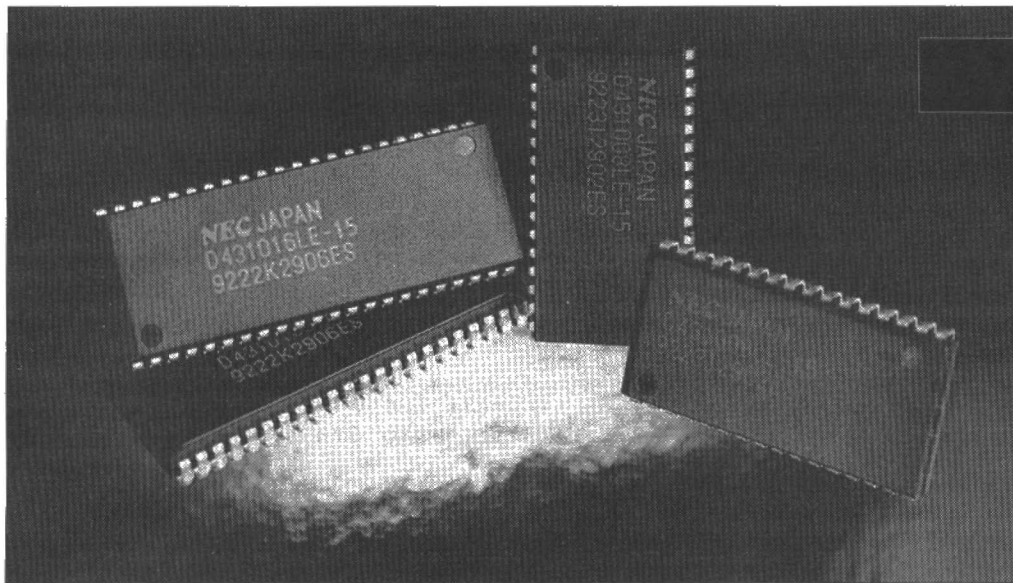
The Conference intends to give delegates the opportunity to broaden their awareness of many non-engineering factors which combine to make successful products and services.

For further information on the Conference please contact: Joanne Jones, Conference Services, IEE, Savoy Place, London WC2R 0BL. Tel: 071 344 573.



## 1MBIT SRAMS

NEC Electronics has announced a range of high speed 12 nanosecond, 1Mbit CMOS static RAMs.

The uPD4310XX products are claimed to be the first available 1Mbit devices to have the ground and power pins in the centre of the package, to minimise ground bounce.

The four products in the series are arranged as 64K x 8 bits with a 9 bit parity version and 128K x 16 bits with an 18 bit parity version. The parity versions are suitable for high speed RISC designs and cache memories. All of the products run from a single +5V supply rail and options are available for 12, 15 and 20 nanosecond access times. Ground bounce is becoming a serious high speed logic problem and occurs at major output changes, for instance when all output bits except one change simultaneously from a logic high to a logic low, with one output remaining low.

In this case the single logic low output voltage may rise slightly and be interpreted as a logic high state. Positioning the GND and Vcc pins at the centre of the package as opposed to diagonally opposite corners, reduces lead inductance and significantly alleviates the problem. The company also plans to use this pin arrangement on all future SRAM development, providing full pin-for-pin compatibility and upgradability throughout its range.

The uPD431008 is arranged as 128K x 8 bits wide and is packaged in a 32-pin, 400 mil SOJ. Its 9 bit wide parity version is the 4PD431009 which is packaged in a 36-pin, 400 mil SGJ. The uPD431016 is arranged as 64K x 16 bits whilst its 18 bit wide parity version, is designated uPD4310018. Both are available in either a 44 pin 400 mil SOJ or TSOP (type 2) package.

Contact: Chris Havell, NEC Electronics (UK) Ltd, Tel: 0908-691133.

## HIGH QUALITY DMMS

The three new Series 10 DMMs by Fluke are now available from Alpha Electronics. Designed to support first level electronic and electrical troubleshooting, their compact shape with slide switch and push button controls allows one-handed operation. All the family offers ac and dc volts, ohms, diode test, continuity bleeper, easy to read 4,000 Count digital display, autoranging and sleep mode to preserve battery life.

Model 10 is the lowest cost model, while Model 11 has the addition of VChek to simplify the safe measurement of power sources and supplies as well as Capacitance with auto or manual ranging from .001 to 999µF and to 9,999µF. Model 12 combines all the features of the other two plus Min/Max Record with a Relative Time Clock to take readings over a 100 hour period without the operator and Continuity Capture, which collects intermittent opens and shorts down to 250µs.

All are designed with safety in mind and run continuously for 650 hours on alkaline batteries, or 450 hours on Carbon-zinc. They
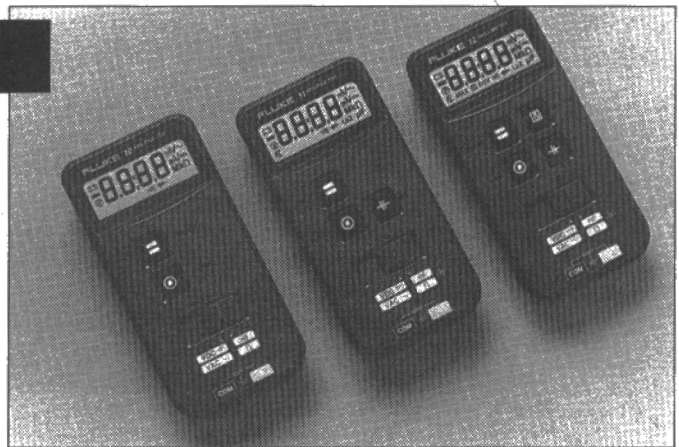


are fully guaranteed by Alpha for 3 Years.

Price of the Model 10 (excl. VAT) is £48.95 and for further information please contact:
**Fred Hutchinson**
**Quiswood Ltd**
**(0756) 799737**

## MITSUBISHI MICROCONTROLLERS

Mitsubishi has announced the introduction of two additions to its 7702 Group of 7700 Series, 16bit microcontrollers, featuring the largest on-board memory so far available from the company. The 7702 is a single chip design and is available in two versions providing either high speed or 3V operation with 48k of ROM and 2k of RAM.

Mask and OTP versions are packaged in 80 pin quad flat packs with EPROM supported in 80 pin glass sealed LCCs. The silicon gate design is suitable for applications ranging from dedicated portable computers to telecomms including CT2 and DECT. The chips are said to provide ideal processing solutions where low battery power usage is a major requirement. Features include 16Mb of address space, three instruction queue buffers and two data buffers enabling high speed instruction execution.

The 16 bit devices are also software switchable, allowing 8 bit parallel processing operations to be carried out. The devices incorporate seven external inter-

rupts, eight 16 bit timers and two USARTs. Up to 68 I/O ports are programmable and an eight channel, 8 bit analogue to digital converter is on-board.

The 25MHz version operates from 4.5 to 5.5V supplies and consumes 6mA at 5V. The 8MHz device operates from 2.7 to 5.5V supplies and consumes 4.0mA at

3V. The 25MHz microcontroller has a minimum instruction speed of 160ns, while the 8MHz version's minimum speed is 500ns. The devices are capable of oper-

ating over temperatures ranging from -20 to +850C and -40 to 850C for the 25 and 8MHz versions respectively.

# THE WORLDS MOST POWER EFFICIENT DSP

AT&T Microelectronics has released what is claimed to be the world's most power-efficient DSP, the DSPl6l6-x30 Piranha. The Piranha can be used with any supply voltage between 2.7 and 5.25V, drawing current of less than 1mA per MIPS when active at 2.7V and including standby modes which can reduce current to less than 100μA.

Able to handle up to 26 million instructions per second (MIPS) when powered at 2.7V, the processor is designed for use in portable applications, particularly cellular handsets for the European, Japanese and North American markets. To cater for increasingly compact designs, the chip is housed in a thin quad flat pack (TQFP) which is 196mm sq. and stands 1.5mm high.

"The next generation of wireless communications terminals will use 2.7V power supplies,"

said Charles Louisson, European manager for DSP products. "The DSPl6l6-x30 provides sufficient processing power for any of the standard cellular telephony algorithms. For this reason, it will become the first choice for such applications, where squeezing the most talk time out of battery life is the number one customer concern."

The Piranha performs at up to 50MIPS when powered from a 5V supply. Its power management facilities allow on-chip peripherals to be selectively disabled, giving the designer flexibility in trading-off power reduction and power-up time.

The DSPl6l6-x30 supports all cellular standards, including the Global System for Mobile Communications (GSM), the Japanese Digital Cellular (JDC) specification, and the interim digital standard (IS-54) for Advanced Mobile
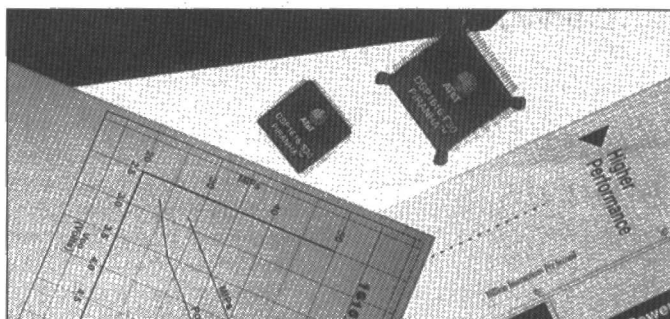
Phone Systems (AMPS) The device is object code and pin-compatible with the DSPl6l6-x 10, with an instruction set optimised for signal coding, which allows it to perform the Vector Sum Excited Linear Predictive (VSELP) speech coding algorithm at less than 17.8MIPS, consuming 48mW at 2.7V.

The JDC VSELP implementation runs at 18MIPS with a consumption of 48.6mW, while GSM

full rate speech coding requires 4.7MIPS, consuming less than 13mW.

Contact:
**Keith Allen**
**AT&T Microelectronics**
**Powell Duffryn House**
**London Road**
**Bracknell**
**Berks**
**RG12 2AQ**
**Tel: +44-344 865927**
**Fax: +44-344-865923**

# EPROM PROGRAMMER - EMULATOR
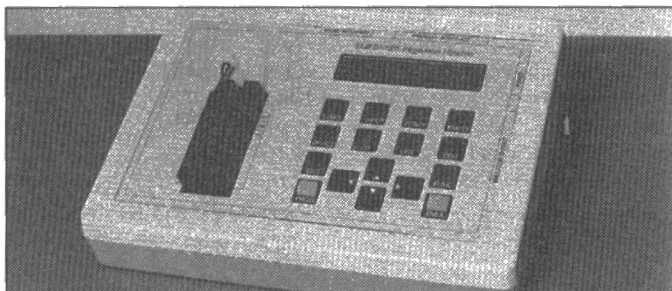
The new SP1000, designed and manufactured by SAJE Electronics is described as a low cost, stand alone EPROM Programmer and EPROM Emulator with the extended power of a PC via remote control link.

The SP1000 incorporates a 16 character supertwist backlit display with an integral keyboard.

The programmer supports most EPROMs, EEPROMs, Flash and OTPs devices up to 1Mbits and is expandable to 4Mbits. Standard features include device select, list, edit, verify and empty. The emulator can be used with

the programmer or independently and supports most 24, 28 and 32 pin EPROM devices up to 1Mbits, again expandable to 4Mbits. The PC interface is fully operable via the serial or parallel ports, to provides a fast transfer. The standard upload and download formats include Binary, ASCII, Intelhex and Motorola.

The SP1000 is priced at £299.00 plus VAT.

For further information please contact:
**SAJE Electronics**
**Tel: 0223 425440**

# ELECTRONIC VERSION OF ELECTRONICS LETTERS

Electronics Letters, the prestigious biweekly journal of international electronics research, will soon also be available as an online journal beginning in October 1993. Electronics Letters Online will be published by the Institution of Electrical Engineers (IEE) and distributed to subscribers by Online Computer Library Centre (OCLC) via Internet and dial-up telecommunications networks.

The new electronic journal will carry the same 1,400 to 1,500 articles per year as the print version, but will display them through the GUIDON interface, a Windows-based graphical user interface developed by the computer library centre.

GUIDON supports full-text searching by subject, title, author, keyword, date and a full range of Boolean and proximity operators. It displays full text, figures, tables, and equations to a quality that is said to rival the printed page. GUIDON operates

in the Microsoft Windows environment on an 80286 or higher PC. Electronics Letters Online will also be available with command-driven ASCII user interface that runs on a terminal or PC with software emulating a VT100 terminal.

Subscribers to Electronics Letters Online will also have access to abstracts of references cited in the articles.

Subscription pricing and ordering information for Electronics Letters Online will be announced soon.

Electronics Letters Online will be the second electronic journal to be launched - the first was the Online Journal of Current Clinical Trials published by the American Association for the Advancement of Science.

OCLC is a nonprofit computer library service and research organization whose computer network and services link more than 16,000 libraries in 47 countries and territories.

# ETI NEWS
## ...Stateside...

## Reading the signals

The trend towards multi-media and portable communications is making relentless demands on digital signal processing technology.

With this in mind, Jan Rabaey, an electronics engineer at Berkeley, along with Dev Chen at Sun Microsystems Inc. (Mountain View, California) has devised a new architecture for signal processing applications. "Instead of viewing computation in terms of taking data from memory, operating on it and then returning it to memory, we simply place logic directly into a data stream, to yield faster throughput and better hardware utilisation,"

## Conduct unbecoming

While most silicon devices can be replicated in conducting polymers, one problem facing practical applications is the migration of electric parameters during standard polymer processing. Now, a new electrolytic process,

says Rabaey.

The pair analysed a cross-section of DSP algorithms - everything from a time-warp speech processor to a video RGB-to-YUV converter - to determine an irreducible base of computational elements for their reconfigurable architecture. The new design retains such conventional architectural elements as word-wide data paths and commonly used arithmetic operations to facilitate the implementation of DSP algorithms. Rabaey continued "In theory, field-programmable hardware allows you to organise an algorithm at the bit level, but in practice that can turn into a frustrating exercise. Bit-level parts such as commodity field-programmable gate arrays do not facilitate the high throughput of world-wide data paths required in DSP

devised at the University of Minnesota's Department of Chemical Engineering may solve this problem.

Polymer wires of various shapes have been produced by pumping a polymer solution past electrodes. Electric current flowing in the solution causes the conducting polymer molecules to form along the current path. Different configurations are created by vary-

architectures."

The goal in devising the new architecture was to provide full coverage for the entire class of DSP algorithms with a small set of reconfigurable computational elements. Rabaey reasoned that such an architecture would optimise both flexibility and raw throughput and would thus provide the best hope for addressing the needs of multi-media computing.

The resulting architecture uses field-programmable processors, called execution units (EXUs), organised in clusters of eight via a field programmable crossbar switch. Each EXU accepts word-sized operands and contains hardwired add/subtract, shift, compare and multiplexing logic.

The new approach to parallel architecture allows a system to

ing the shape of the flow chamber and the process greatly simplifies the formation of conductive polymers, reducing a complicated multi-step process to just one step.

Lightweight battery terminals, electrochromic displays and anti-corrosion films are some of the application areas in which conducting polymers could make a unique contribution.

scale up while retaining the ability to commit hardware to computationally intensive inner loops. A benchmark study for a variety of algorithms all running at a 25MHz sample rate shows how scalability addresses a spectrum of applications.

The project has produced an eight-processor chip built in 1.2-micron CMOS technology as a proof of concept. Running at 25MHz, the chip has an I/O throughput of 200Mbits/second and is rated at 400Mips.

In comparison, a Motorola DSP56000 operates at 10.25 Mips and has a data I/O bandwidth of 60Mbytes/s. For video sampling rates, that represents only two instructions per sample.

## Electric Avenue

Electric highways could be the road forward for transport in the 21st Century, with the announcement of the E-Tran Electrified Roadway and Electric Vehicle System, invented by Nick Musacio from Minnesota. This giant Scalextric set feeds power to vehicles directly through power strips embedded beneath the roadway.

The strips connect to buried power lines by solid-state power controllers, which switch on only when a vehicle signals them. The absence of an E-Tran vehicle directly overhead assures the safety of the roadway.

The patented E-Tran system uses Turck Inc.'s Permaprox sensors and Musacio approached Turck when trying to isolate the roadway's electrical power strip from its control circuits. The proximity sensors are totally solid state, with no moving contacts and have a patented magnetic circuit. They are available in AC or DC mod-

## Food for thought

Scientists at ATE Bell Laboratories, who previously replaced chlorofluorocarbon (CFC) solvents with derivatives of orange peel and cantaloupe, are now

els, with or without quick-disconnect and are short-circuit and overload protected.

The power strips are fitted with heating cables to melt snow and ice on the roadway. Braking or stopping deactivates the system.

It is estimated that it would cost $400,000 per mile to convert an existing roadway to the system, or less than $1 million per mile for two E-Tran lanes, one in each direction. In comparison, light rail installations are estimated to cost $15 to 25 million per mile and traditional roadway construction is about $40 million per mile.

starting to use food ingredients as the basis of a family of solder pastes that eliminate CFCs in some circuit-board manufacturing processes.

"Many of the chemicals we used can be found in the lists of ingredients on chewing gum or hand lotion," said a Bell Labs spokesman. The specific chemi-

## Producing micro-channel plates

Galileo Electro-0ptics Corp., has received $1.9 million from the US Department of Commerce's Advanced Technology Programme to adapt nanofabrication techniques to try to lower the cost of producing micro-channel plates.

A micro-channel plate is an array of up to millions of microscopic channels, each acting as a multiplier. When an electron, photon or ion enters a channel on

cals remain proprietary.

The new flux formulations in the solder paste can be cleaned away with water and they exceed insulation standards set for such compounds by Bell Communications Research Corp. Inc. In addition, they produce no malodorous vapours and pose no problem with skin contact.

one side of a plate, it triggers a cascade of electrons flowing out of the other side. Microchannel plates are used in extremely sensitive imaging equipment - night-vision equipment, for example - and could be used in scientific instruments.

Less expensive image intensifiers would make commercial night-vision devices cost-effective for law enforcement and as an aid to the estimated 400,000 Americans who suffer from retinitis pigmentosa, a narrowing of vision that leads to night blindness. They could also be used to develop compact, low-cost mass spectrometers for field detection of pollutants and field drug analysis for law enforcement.

## Symbols Convention

You recently invited opinions concerning the presentation of circuit diagrams in ETI. Having followed these hallowed pages as amateur and professional for nearly 20 years, I have something to say on the matter.

When I see a circuit diagram, I want to be able to read it like words in a book. For this to be possible the symbols used must be instantly recognisable and, if possible, be symbolic of the function of the components they represent. The capacitor is a good case in point, the symbol illustrating two plates separated by an insulator.

The symbol for a coil, inductor, or transformer is also obvious (or would be if the loops hadn't shrunk to nothing). By extension, the variation applied for an electrolytic capacitor is also easily assimilated. The diode is good, the combination RI an arrow and a bar suggestive of allowing current flow in one direction and blocking in the other. Of course, there is a multiplicity of symbols for the many variations on the transistor and FET, but I would suggest that they are not unreasonable.

What has crept in, however, is the 'unencapsulated' form, by which I mean the transistor symbol minus its surrounding circle. To me, the circle represents the packaging of the component, separating the elements on the inside from the rest of the world. The unencapsulated form is best reserved for manufacturers schematics of IC innards, where the transistors are fabricated on a single piece of silicon and only encapsulated overall. This applies to things like Darlington drivers, where a two-transistor combination would be shown within a single envelope. By this means it is clear what is part of the device and what is part of the external circuit.

The resistor is really irritating. The good old zig-zag line was quite suggestive of something which resists the flow of current. The new rectangle carries no such suggestion, or at least not for me.

BS3939 is the current standard for component representation on circuit diagrams, particularly for logic. Most electronics companies have to use it these days, as contracts placed with them often specify that BS3939 is to be used in any documentation supplied. It provides a method by which a symbol representing any logic function can be created, though it has its problems in that complicated logic functions produce excessively large symbols, and two people can devise a yMol for a particular component and produce entirely different results, even though they used the same set of rules! Wireless World ran a good series of articles on BS3939 when it was new. Having said that, I don't personally find the BS3939 symbols for the simple logic functions like a NAND or NOR gate as recognisable as the old curvy shapes. I have heard it said that one of the reasons the BS3939 system is based on boxes is to make it easier for computers to draw the diagrams - I spent years drawing the curvy ones with a stencil and thought that computers didn't mind a bit of hard work! Although ETI does use the curvy symbols for simple logic functions, I'm afraid it leaves much to be desired with respect to more complicated devices.

It's not good enough to give up and draw a big rectangle with some pin numbers around it. BS3939 can be applied in a simplified form and produce symbols on a reasonable scale which still convey a fair amount of functionality. I would even be prepared to put up with BS3939 NAND and NOR gates in exchange for this.

When all is said and done, these are your pages and you can draw your diagrams however you like. There is a lot to be said for consistency and if the readers are used to reading circuit diagrams your way, then that is a strong argument for not changing anything. I also don't approve of having standards imposed for the sake of it. Vive la difference. But, if you want my opinion, my recommendations are these:

1. Drop the rectangle in favour of the zig-zag resistor.
2. Bring back loopy inductors.
3. Put a circle around the transistor symbols, or an overall outline around multi-transistor devices.
4. Adopt a variation on BS3939 for logic symbols.

In this modern day world of CAD packages running on desktop PCs to draw diagrams for you (unheard of in my early days), there should be no trouble implementing any of this.

**Ken Wood**
**Newbridge**
**Gwent**

---

In the March edition of ETI you asked for reader's comments on schematic symbols resulting in various letters on the subject Published in the May edition.

Personally, I prefer zig-zag resistors, semiconductors enclosed in circles and polarised capacitors with blocked-in negative plates.

However, I think the far more important issue is whether the choice of symbols for ETI should be based on the idiosyncrasies of a few readers such as myself.

The scientific and technological world has long been aware of the overwhelming advantages of defining and adopting common standards even when these may not agree exactly with individual preferences. Look back at the topics in Open Channel over the past few months if you are not convinced of the importance of standards to industry!

As a magazine that is closely concerned with technology, ETI should follow this example. The national standard for schematic symbols, BS 3939, was agreed many years ago and its time that ETI conformed.

Incidentally BS 3939 does recognise the zig-zag resistor although the block is the preferred form.

**A Chadwick**
**Hull**

## EPROM Programmer Software version 2

A few users have had problems installing or using my EPROM Programmer control software version 1.00, on certain compatible PCs. Version 1.1 is now available, which addresses these problems. If version 1.00 is working for you there is no advantage in obtaining 1.1.

Any user who feels he needs a copy of version 1.1 should request this as described in the software documentation file. A description of the problems you are having with version 1.00 must also be enclosed.

**Paul Stenning**
**Hereford**

---

## Faulty Diagnosis

In a letter in the May issue entitled Spotting the Fault, a reader suggests that it might be possible to identify faulty ICs by using heat sensitive paint to detect a rise in temperature. Attractive though this idea may sound it is flawed for two reasons.

Firstly, in my experience failure of the majority of ICs does not lead to any significant rise in temperature. The writer's suggestion that 15-20% of failures could be detected in this way is optimistic.

The second problem is that many ICs run warm or even hot when operating normally. Typical examples are microprocessors, D-A converters, power driver ICs and regulators. Unfortunately it is often these types of components that fail.

The author also seems confused as to whether or not excessive fault currents cause a device to heat up significantly, suggesting incorrectly that a fuse reaches an extremely high temperature for a brief period before failing.

Although the actual wire must do so, the body of the fuse normally does not, particularly when the overload is severe and so the fusing time is short.

This is because under normal conditions the heat generated in the fuse wire is small and can easily be dissipated to the fuse body which will indeed get slightly warm, as the author states. However, under overload conditions the rate of heat production in the fuse wire far exceeds the rate at which it can be dissipated and so its temperature rises rapidly to its melting point and the fuse 'blows'. The heat energy produced in the fuse wire during the fault is subsequently dissipated and absorbed by the fuse body. The thermal capacity of the fuse body is large compared to the quantity of heat energy involved and so the temperature rise is insignificant.

**A Chadwick**
**Hull**

## Fetlington

I was recently browsing through the October 1992 edition of ETI and was intersted in an article called Rapid Fuse Checker by Mark Daniels. However, when I checked through the requisite components I found that component Q3 - 2N7000 described as a MOSFET is in fact a bipolar transistor ie a Fetlington.

I would greatly appreciate some clarification on this point.
**D J Dyer**
**Swansea**

*The type number specified as 2N7000 is correct and is an n-channel MOSFET. It is also called a FETlington as it is a cross between a FET and a Darlington arrangement. It is not a bipolar transistor. Judging from this and the following letter seems it would be wise to provide an article on the subject! - Ed.*

## Tech Tip Return

I've been taking ETI now since last November and it continues to be a fine magazine. May I say that since no one else seems to have done so, you ought to be thanked for the steady supply of cover PCBs, each worth around

twice the cover price! I was, however, looking forward to more Tech Tips (I have a large collection old ETIs and am forever collecting these as reference material) but few Tech Tips have turned up and one of your correspondents notes that some are regurgitations from the past. If you are thinking of repeats could you do so from the late '80s, my collection stops around there.

Regarding the discussion of new versus old circuit symbols, I would choose according to what is easy and neat to do by hand - old style resistors are neater and faster than boxes, transistors in circles are difficult and untidy. Also, I never liked the half curved capacitor symbol. Whatever happened to the iron core in coil devices such as relays? The new logic symbols are an improvement. Could we have a brief article on the latest devices and their symbols?

**R Crawley**
**Hitchin**
**Herts**

## The Spoiler

Many thanks for 'The Spoiler' by Anal Bardfrod in your April edition. The irregularly spaced legs and the 'CA3080 poor noise performance' were especially clever touches.

However, there is shurely a serious point here. Excluding tape hiss, the pleasantries of recorded music replay are not due to the cleanliness of digital precision, but the ideosyncracies of analogue workings: the difference between a Yamaha violin and a Stradivarius.

By the way it took me ages to work out that Anal Bardfrod was not an anagram of April Fool.
**N C Fairman**
**Sturry, Nr Canterbury**
**Kent**

I made up your circuit but it wasn't bad enough, so I fed the output to an old car speaker and the pick-up to an equally old moving iron microphone.

The spikes were still not bad enough so I junked the lot and bought a Dansette at a car boot sale. Absolute bliss!

Your designer should use his head not his name.
**J O L Smith**
**Hythe**
**Kent**

## Safety Boots

I have read the letter from Ian Benton regarding projects which have appeared recently in ETI using mains supply. I am in 100% agreement with him regarding safety aspects when home building this type of equipment. In the same issue, mains safety has been considered by Bob Noyes who recommends the use of IEC connectors. The only aspect not mentioned in that article is that boots must be fitted over the internal socket connections with insulating sleeves over the female spade terminals. It is not enough to use the pre insulated crimp connectors as the crimping process exposes some area of metal. If insulating sleeves are not available, amalgam tape can be substituted.

The reply about televisions and their power supplies is irrelevant as if you look at a TV then there are absolutely no metal parts that can be touched directly. They are double insulated units, conforming to international safety stadards marked on the rear cover. The metal looking knobs are plastic fakes made to look like metal. However Mr Benton specifically refered to a metal touch plate

connected directly to equipment which could be the source of a considerable voltage. If all this is academic then why has Tatung recently reworked a few thousand sets to meet European safety standards and is the British Standards organisation wasting it's time?.

I was going to build the Amiga board until I looked at it closely. I certainly have no desire to use a board which attempts to separate the mains from the 5V of the computer by a hairs breadth, negating the function of the opto isolators.

On the positive side, as Mr Benton appears to be so knowlegeable in the area of mains safety then you could consider asking him to vet projects before publication. Come on. You are wrong on this one and a bit of humble pie would not come amiss.
**H D Briggs**
**Telford**
**Shropshire**

*Thanks for the portion of humble pie. An article on electrical safety is in preparation for anyone wanting to build mains projects for themselves or for publication in ETI. An article on transformerless supplies is also in the pipeline - Ed.*

# Microwave Monitor

### A Simple Field Strength Monitor, by Ian Hickman

A simple field strength monitor can come in handy for many purposes. The one described here started life as a leakage monitor for microwave ovens, but along the way its use has been extended by designing it to take alternative plug-in measuring heads for use at other frequency bands. It is built in a hand-held box of the calculator style and powered by an internal 9V PP3 battery.

The On/Off switch is a simple push-button, avoiding the possibility of the battery being drained if the unit is accidentally left on. All the parts are readily available and indeed many keen constructors will already have most of them in stock.

## Design considerations

The simplest form of field strength monitor consists of an antenna, resonant at the frequency of interest, feeding a diode detector whose output drives a sensitive meter. Such an arrangement is not very sensitive, although it could detect



Fig.1 Basic monitor circuit
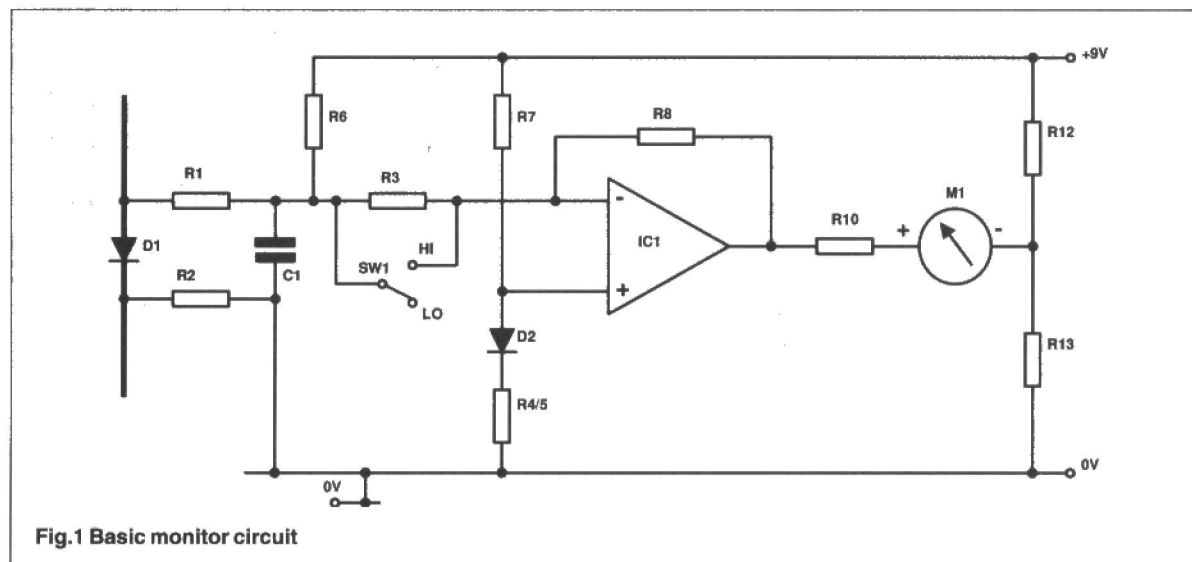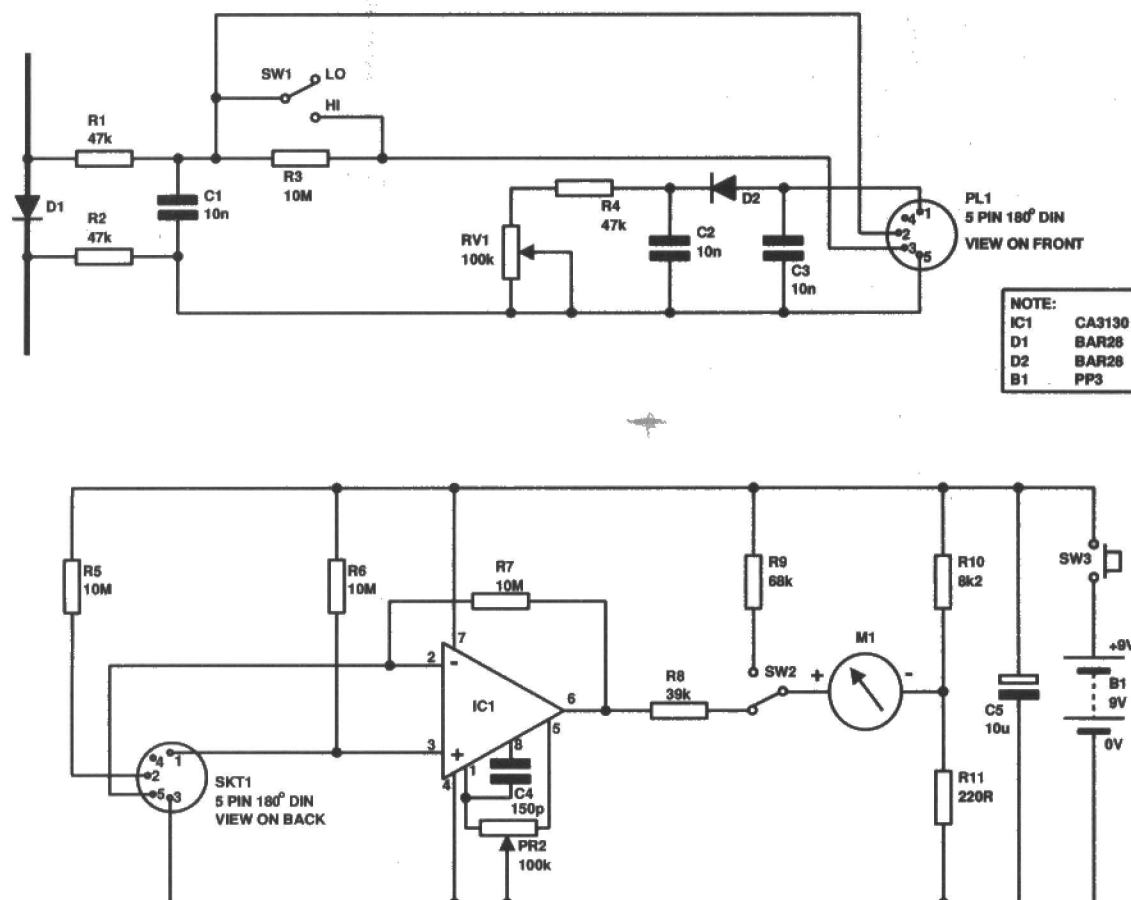
**Fig.2 Final version of circuit showing probe arrangements**

NOTE:
| | |
|---|---|
| IC1 | CA3130 |
| D1 | BAR28 |
| D2 | BAR28 |
| B1 | PP3 |

## HOW IT WORKS

This is best explained with reference to the simplified circuit diagram shown in Figure 1 (where the component references are the same as for the full circuit diagram, Figure 2). The diode D1 is situated at the centre of a receiving halfwave dipole. For a microwave oven monitor, the unit has to work at 2450MHz, at which frequency a half wavelength amounts to 61.2mm. However, the electrical length of a halfwave dipole with thin arms is 2.5% longer than its physical length, so the dipole should be just a shade under 60mm (59.7mm, if you can work to that accuracy!). A halfwave dipole is a balanced antenna, whereas its output is connected to unbalanced circuitry; the two resistors R1 and R2 are therefore used to avoid upsetting the balance. The sensitivity of the Schottky (hot carrier) detector diode is increased by applying a small forward bias current via R5. This results in a small standing DC potential difference between the two halves of the dipole, which has no effect on signal pick-up. However, it does result in a standing voltage at the inverting input of IC1, which is balanced out by another similar diode, D2. RV1 is a preset variable, to allow exact equalisation of the standing diode voltages at the op-amp's inputs. C2 and C3 bypass diode D2 at RF, to ensure that RF is detected only by D1. At the low sensitivity setting, the detected voltage (which is negative and appears across the RF bypass capacitor C1) is applied to the op-amp via R3. Since this has the same value as R7, the op-amp operates at a gain of $X(-1)$, driving the meter M1 via R8. At the high gain setting, the gain is $X(-100)$, since the op-amp's feedback resistor R7 is one hundred times the signal's source resistance (R1 + R2). It should be noted that the gain of 100 does not provide as much as a hundred fold increase in sensitivity to field strength, since with small signals, the diode will be operating down in the region where it exhibits a square-law response. The offset at the meter's negative terminal, provided by R10 and R11, avoids a change in meter zero reading when changing between sensitivity ranges. The meter can also be used to check the battery voltage, in one position of SW2.

excessive leakage from a microwave oven. However, it could also lull one into a false sense of security, since the normal result with an oven in good order is 'no deflection'. If the unit ceased to work, one would never know and if the door seals on the microwave oven then deteriorated, one would be lead to think all was well when in fact they weren't. The monitor presented here, therefore, has a high sensitivity range which will detect the minuscule residual leakage from an oven in good order. Knowing what to expect, one can then periodically check the oven and observe if the leakage is still the same, or whether it has increased significantly. The extra

sensitivity is provided by an op-amp, which can be switched to amplify the detected voltage by unity or by a factor of x100. The circuit is powered by a 9V PP3 battery housed within the handheld case.

## Construction

The monitor is constructed as two separate units, the main unit containing the battery, meter, op-amp, etc., being mounted in a calculator style handheld case (Figure 2b). This permits different diode detector heads to be plugged in to the 5-way 180° DIN socket on the main unit, providing coverage of

different frequency bands. Since the dipole for a microwave oven monitor is so short, it and all the related components including the 5-way DIN plug can be mounted on a piece of SRBP strip board (Figure 2a). Make the dipole over long at this stage, say 70mm. A small PC mounting preset pot was used for RV1 and a miniature PC mounting slide switch for SW1. Schottky diodes type BAR28 work well at D1 and D2, but I have also used HP82 2303s and doubtless most small-signal Schottky types would be suitable. If you have them in stock, you could probably even use that venerable point contact device, the GEX66, although they are a bit big - it is best to use all miniature components, at least for the probe.

The components in the main unit, (Figure 2b), can be mounted on a scrap of SRBP strip board or on a bespoke PCB. This is secured in the base of the case on three bosses, using self tapping screws. A small moving coil indicator, such as those sold as stereo level or VU meters, was used for M1, rescaled 0 to 8 in eight equal divisions. The graduations are arbitrary, as these small meters are usually non-linear. Full scale deflection for the one used was 120µA.

If a movement with a different sensitivity is used, R8 and R9 should be changed accordingly. R9 is selected to give a convenient deflection, such as 6 on the meter, when a fresh battery is fitted.

SW2 and SW3 were mounted on a scrap of SRBP and mounted in the window of the case, as was M1, after widening the window slightly. They were secured in place using Evostic Time Bond, an excellent general purpose adhesive. Socket SK1 was mounted on long 6BA screws at the opposite end of the case from the built-in battery compartment.

When you've completed the construction, check all soldered joints with an eyeglass and make quite sure that the battery connector is connected to the circuit the right way round. If using stripboard connection, double check that the circuit is correct and that all the necessary track breaks have been made. Mount the op-amp in a socket, just in case. For neatness, short pieces of ribbon cable can be used to connect from the circuit board to the front panel meter, etc., and to SK1.

## Testing

Assuming the unit is to be used as a microwave oven monitor, trim the length of the dipole on the probe to 60mm. Set both variable resistors to mid travel and connect the probe and a fresh battery. Set SW2 to battery check position and press SW3. The meter should read around 6 on the scale - change the value of R9 if necessary and scale R8 in the same ratio. To set up the Measurement function, proceed as follows. Set SW2 to MEAS, set SW1 to the LO sensitivity position and connect a 10k resistor between pins 1 and 5 of PL1. Wait five minutes to ensure that both diodes have settled exactly to room temperature and then adjust PR2 so that the meter reads zero. Remove the 10k resistor, set SW1 to HI sensitivity and wait as before. Adjust RV1 for zero reading on the meter. To check that the circuit detects a small change of voltage across D1, touch D1 with a warm finger tip: at HI sensitivity, a small positive deflection should result. Wait, then touch D2, and a small negative deflection should be seen. The unit is now operational and on the HI sensitivity setting should detect the residual radiation through the mesh window in the door of a microwave oven at various points, when placed close to, but not quite touching it.

## In Use

The microwave monitor can be used among other things to check for deterioration of the door seals of a microwave oven. Though not providing an absolute measure of field strength, its regular use will alert the user to any such deterioration in good time. When you buy a new microwave oven, check the level of emission all over and particularly around the edges of the door. The worst spot is often the corners of the door away from the hinge. Note the readings and the distance from the oven at which they were taken.

**Fig.3 For lower frequencies, a compact antenna is convenient**

a) NMHA design

For a typical design , $D_h = 0.35 \times 10^{-2}\lambda$    $p = 0.4 \times 10^{-2}\lambda$

$2a = 0.13 \times 10^{-3}\lambda$    $\lambda = \left(\frac{300}{f_{mhz}}\right)$ metres

b) Design for 2m amateur band
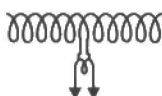
NMHA with parameters as at a) and 6 turns each side is resonant, i.e. needs no tuning components.
For 144-146 MHz (2m) band,

$\lambda = 2.069$ metres, so    $D_h = 7.2mm$

$2a = 0.27mm$

$p = 8.3mm$

Output impedance is approximately 12R resistive, so a 2:1 turns ratio transformer is used to raise this to 50R approximately.

As it is not advisable to run an oven with nothing inside it, a Pyrex bowl of water should be placed on the turntable. If placed centrally, the field distribution will be constant and steady readings will be obtained. If it is placed off centre, significant variations of field strength will be observed as the

PROJECT

turntable rotates. If you already have a microwave oven, then as a guide, the meter reading due to emission from areas around the edges of the door should not greatly exceed the highest reading obtained through the window - this is a sheet of metal with holes much smaller in diameter than the wavelength of the radiation and hence acts as a wave guide beyond cut-off, providing high attenuation of the internal field. Note that the reading obtained in front of the window will itself vary quite widely at different points. It's recommended that you cross check the operation of the device on another oven, preferably a new one. Please note, however, that as the conditions of construction and use of the monitor described are beyond their control, neither the author nor the magazine gives any warranty, explicit or implied, that the above procedure will invariably indicate a dangerously faulty oven.



**Fig.4 Component overlay**
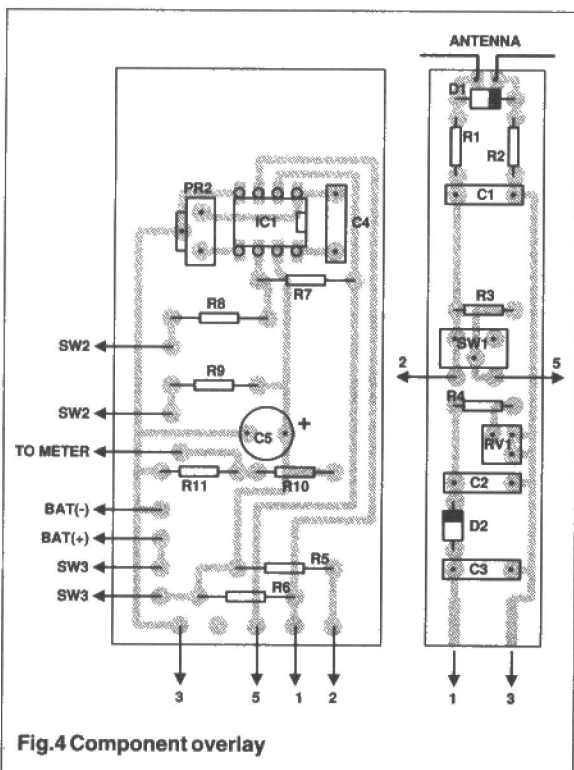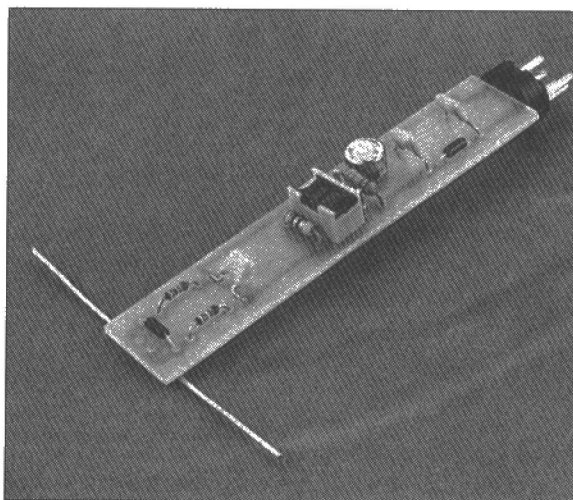
and not simply warming up a corroded junction box. The antenna can be made more compact by using a helical design, as indicated in Figure 3; a Normal Mode Helical Antenna achieves maximum pick-up at right angles to the incident field like an ordinary dipole, but unlike the more usual helical which is an end-fire antenna. For more details see Ref. 1. With a probe using an appropriate antenna, the unit could also check the radiation from a car 'phone or even a handheld. For those wishing to experiment further with field strength measurements, at 144MHz a 400mm dipole will deliver -4dBm into a 50ohm load, in a field strength of +26dBV/m, falling at 6dB per octave at lower frequencies.

## Reference

**Small Antennas,** Fujimoto et al., Research Studies Press. ISBN No. 0863800483
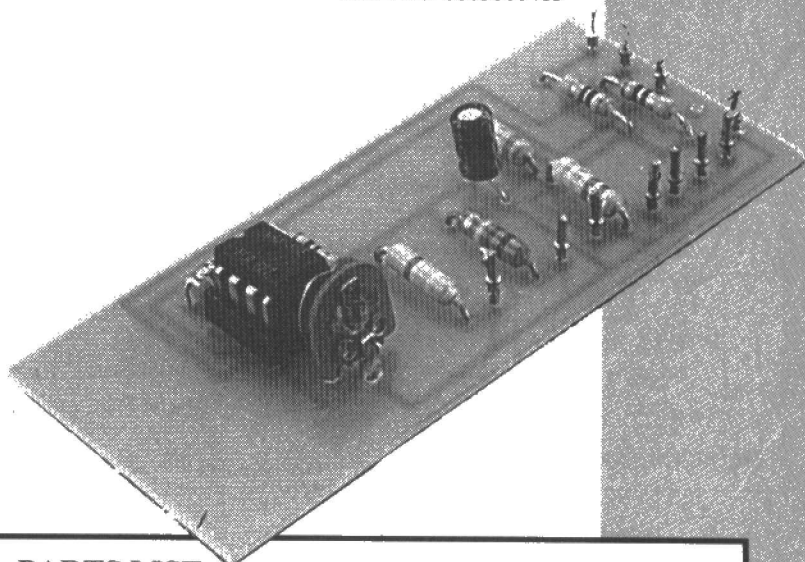
The unit will also detect radiation at lower frequencies, where the antenna, being electrically short compared to a wavelength, acts as an E field probe. For example, on the HI sensitivity range, a deflection of one eighth of full scale was obtained when the probe antenna was placed close to a similar antenna connected to a signal generator producing an output of 100mV at 100MHz, while with a 10MHz signal at 6V RMS connected to a 25cm short dipole, a full scale reading was obtained at a spacing of 3cm. However, much greater sensitivity will be achieved if a probe is used where the dipole is resonant at the operating frequency. For example, at 144MHz, the length of the dipole should be 1016mm. As this is a bit unwieldy to mount directly on PL1, it should be mounted on a separate handle with a short flexible cable to the main unit. It can be used to get some idea of the radiation pattern of a 2m transmitter; for example, the influence of the bodywork can result in a very strange pattern from a supposedly omnidirectional radiator mounted on a vehicle. The monitor could also be used for checking that radiation really is getting away from a fixed 2m installation



## PARTS LIST

| RESISTORS | | CAPACITORS | | MISCELLANEOUS |
|---|---|---|---|---|
| R1,2,4 | 47k | C1,2,3 | 10n | SW1 ON/OFF min |
| R3,5,6,7 | 10M | C4 | 150p | SW2 SPCO toggle |
| RV1,PR2 | 100k preset | C5 | 10u | SW3 push button |
| R8 | 39k | | | M1 see text |
| R9 | 68k | SEMICONDUCTORS | | PL1 5 pin 180 deg. DIN (inner only) |
| R10 | 8k2 | D1 | BAR28 | SK1 5 pin 180 deg. DIN |
| R11 | 220R | D2 | BAR28 | Stripboard or PCB as required |
| | | IC1 | CA3103 | Antenna 1.0mm tinned copper wire |
| | | | | Case calculator style |
| | | | | Battery PP3 Battery connector lead |

# Car Battery Tester

## by Richard Tant

here's always been one major limitation
using a standard analogue multimeter to te
batteries. The problem is that in order to me
voltages of around 12V it is necessary to s
meter on the 50V range, since the next lowest range is u:
10V which is, of course, too low. This means that the me
resolution is very poor, leading to difficulties when tryi
to check that the battery is actually being charged by tl
alternator.

The quick method of testing the alternator is to
check the battery voltage, with the engine switched



**NOTE:**

| | |
|---|---|
| IC1 | 78L05AWC |
| IC2-5 | LM358 |
| D1 | 1N4148 |
| LED1 | 4x2mm RED LED |
| LED2-9 | 4x2mm GREEN LED |

**LM358 MAY ALSO BE SUPPLIED
AS LM258 IN SMD PACKAGES**
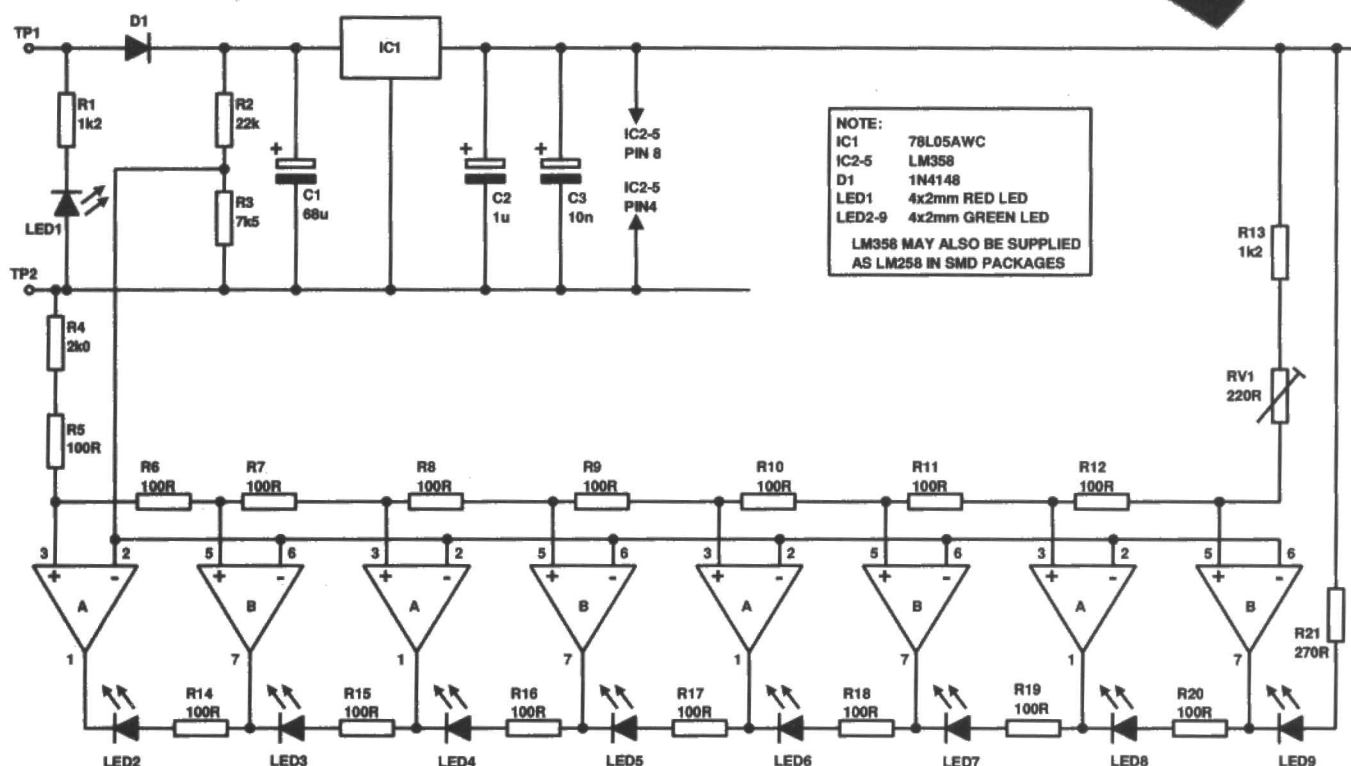
**Fig. 1 Circuit diagram**

off and then with the engine switched on. If the alternator is
working correctly the battery voltage will increase by 1 or 2V
when the engine is running, but a small change such as this
is hardly discernible with an analogue multimeter set on the
50V range.

This led to the idea of building an LED bargraph meter
with a more suitable range. An added benefit is that LEDs are
more durable than moving coil meters, especially in a garage
environment where there will probably be a few unexpected
encounters with the garage floor. The meter also includes a
reverse polarity indicator to warn of incorrect connection but
this could also be used to determine the polarity of an
unknown voltage source.

## PCB Construction

The circuit is constructed on a double-sided PCB meas-
uring 40 x 65mm, using a combination of surface mount and
conventional components. The prototype PCB was created
by drawing the foil pattern using an etch resist pen, which
gives perfectly good results provided that the copper is clean
and that you are careful when drawing the PCB pattern.

Begin assembly by first fitting the through PCB links
(five in all) which carry connections from one side of the PCB
to the other. Commercially produced PCBs have through
plated holes to make the through PCB connections, a process
which involves electroplating copper around the sides of the
holes, but this is not possible with home made PCBs. The

links can be made from thin wire or the clippings from resistor legs. I find it is easier to fit the SMD ICs first, while there is still plenty of room to manoeuvre the soldering iron around them.

Use a small soldering iron bit and thin (24 swg) solder. Take care to fit the ICs accurately over the PCB pads and make sure they are the correct way round. Pin 1 is identified by the side with the chamfered edge (see Figure 2). Then fit the remaining SMD components taking care to fit D1 the correct way round.



**Fig. 2 IC Identification**

large pieces of copper track from the PCB. It is far safer to use a variable DC power supply. Begin by testing the reverse polarity indicator.

Connect the variable supply to TP1 and TP2, positive to TP2. Slowly increase the input voltage towards 12V, monitoring the current if you wish and, if all is well, LED1 should light. If nothing happens check the polarity of LED1 and D1 - if these are correct then check the voltages across LED1 and R1.

Next, reverse the input connections to TP1 and TP2 so that TP1 is positive and again increase the supply voltage towards 12V while monitoring the current. The current consumption should be no more than 30mA and, if it is much higher, check for reversed components and short circuits. If all is well you should see the green LEDs lighting in sequence as the input voltage increases.

The tester is calibrated using PR1. Set the input voltage to exactly 12V and adjust PR1 to the point where LED 4 just extinguishes and LED5 illuminates. Vary the input voltage between 10V and 14.5V to check the operation of all the

## HOW IT WORKS

Power for the circuit is taken from the battery under test through TP1 and TP2. First let us assume that TP1 is connected to the negative battery terminal (reverse polarity). Under these conditions diode D1 is reverse biased and blocks the input voltage. However, LED1 is forward biased and lights to indicate reversed connections.

When TP1 is connected to the positive battery terminal LED1 is reverse biased and does not light. D1 is forward biased and allows current to flow to the rest of the circuit. The 5V regulator, IC1 and C1-3 provide a smoothed supply to the operational amplifiers, IC2-5. This is needed to prevent the circuit from giving erratic results due to voltage spikes caused by ignition noise, but the regulated supply also serves as a constant voltage reference for the non-inverting inputs to the voltage comparators. The values of C1-3 are not critical, so other values may be substituted without affecting the performance.

The operational amplifiers are used as voltage comparators in this circuit. The non-inverting inputs of IC2-5 are connected to various points along a potential divider formed by P1 and R4-13 giving each

input a slightly higher reference voltage than the previous one. The inverting inputs are all connected to the junction of R2 and R3. These two resistors form a potential divider across the input voltage, allowing about one quarter of the input voltage to go to the comparators. When the inverting input of a comparator is at a higher voltage than the non-inverting input, the output will go low and when the inverting input is at a lower voltage, the output will go high.

When the circuit is connected to a battery, the comparators which are referenced to a lower voltage than the battery voltage will give low outputs and the remaining comparators will give high outputs. This means that only one LED will be connected between two comparators which have different voltages at their outputs and this LED will illuminate.

One point to note is that R21 in series with LED9 is a higher value than resistors R14-20. This is because LED9 is powered from the 5V line and the other LEDs are powered from the outputs of the comparators which only give about 3.5V

Fit veropins for TP1 and TP2. Push the pins through from the top side of the PCB so that they protrude on the underside of the PCB. Solder the pins on both sides of the PCB.

The LEDs should be fitted so that they are the right height, above the PCB, to fit closely behind the clear plastic top of the box - use one of the spacers as a guide. Take care to get all the LEDs upright and at the same height, as this has an effect on the overall appearance and quality of the final product.

The remaining components can now be fitted. Note that some components will need to be soldered on top and bottom of the PCB as they connect to tracks on both sides of the PCB. The large electrolytic capacitor, C1, is laid flat to the PCB (Figure 3). The PCB is designed to take two different sizes of pot, so there shouldn't be any difficulty in finding a suitable component for PR1. Finally, inspect your work to check for solder bridges, dry joints, and reversed components.

## Testing

It's not advisable to connect the tester across a car battery for the first time and simply hope that it works. Any short circuits will quickly be removed by the battery, along with



⊕  Ø 3mm HOLE
✕  THROUGH PCB CONECTION

**Fig. 3 Component overlay**

**Fig. 4 Box Construction**

## Box Construction

The circuit can be housed in any suitably sized metal or plastic box which can either be bought or made from a flat sheet of metal (see Figure 4). The top of the box is made from a piece of clear plastic, either acrylic (Perspex) or polycarbonate. The inside surface is painted black except for the area above the LEDs. This is done by covering the plastic with masking tape and accurately cutting out the appropriate pieces with a sharp knife. The lettering can either be typed or applied with rub-down transfers and is fitted to the inside surface of the box top.

The test leads are made from a short length of twin stranded cable (Maplin zip wire) with crocodile clips fitted to the ends. Fit the leads through the hole in the side of the box and solder them to TP1 and TP2, red lead to TP1.

## Further Ideas

The circuit could also be adapted to work on 12V and 24V batteries by fitting a switch to connect another resistor (approx. 5k1) in parallel with R3, to halve the input voltage to the comparators so that it can be used with a 24V input.

### PARTS LIST

**RESISTORS**

| | | |
|---|---|---|
| R1,13 | 1k2 | SMD |
| R2 | 22k | SMD |
| R3 | 7k5 | SMD |
| R4 | 2k0 | SMD |
| R5-12,14-20 | 100R | SMD |
| R21 | 270R | SMD |
| P1 | 220R | |

**CAPACITORS**

| | |
|---|---|
| C1 | 68u/16V |
| C2 | 1u SMD |
| C3 | 10n SMD |

**SEMICONDUCTORS**

| | |
|---|---|
| D1 | 1N4148 SMD |
| LED1 | 4 x 2mm Red LED |
| LED2-9 | 4 x 2mm Green LED |
| IC1 | 78L05AWC |
| IC2-5 | LM358 SMD |

Note: LM358 may also be supplied as LM258 in SMD package.

**MISCELLANEOUS**

Crocodile clips + red and black insulating boots
Twin, stranded core cable, approx. 1 metre.
Box 65 x 40 x 20mm (minimum internal dimensions)
Clear plastic sheet (cut to suit box top)
M3 threaded spacers (cut to suit box)
M3 x 6 countersunk screws
M3 x 6 panel head screws
M3 spring washers

### BUYLINES

The only components which may prove difficult to find are the rectangular LEDs. These were obtained from Greenweld Electronics Ltd., but alternatively, 3mm standard round LED's could be used.

LEDs. Each LED spans an input voltage range of 0.5V. At voltages below 10V, no LEDs are lit. If nothing happens when 12V is applied to the circuit, first check the voltage at the input and output of the 5V regulator, IC1. If this is OK, check that each IC is receiving the 5V supply, then check the reference input to each voltage comparator on resistors R5 to R12. Each voltage should be slightly higher than the previous one. Next, check the other input to each comparator by measuring the voltage at the junction of R2 and R3. This voltage should be about one quarter of the input voltage. If all this is correct, check the polarity of the LEDs.

If only some LEDs light up, check the polarity of the LEDs which don't light and then check the comparator inputs as described above. This fault occurred on the prototype and was traced to a short circuit between pins 1 and 2 of IC3, caused by a solder bridge, which in turn caused the reference voltage to be varied when the output of IC3a changed state.

Remember to upgrade C1 to a 35V capacitor. I am sure that with a bit of head scratching it is possible to come up with many more applications for this type of circuit where a simple voltmeter is needed.

## Safety

One final point to bear in mind when working with car engines. Ensure that the leads of the tester and any parts of yourself or your clothing do not become entangled with the moving parts of the engine.
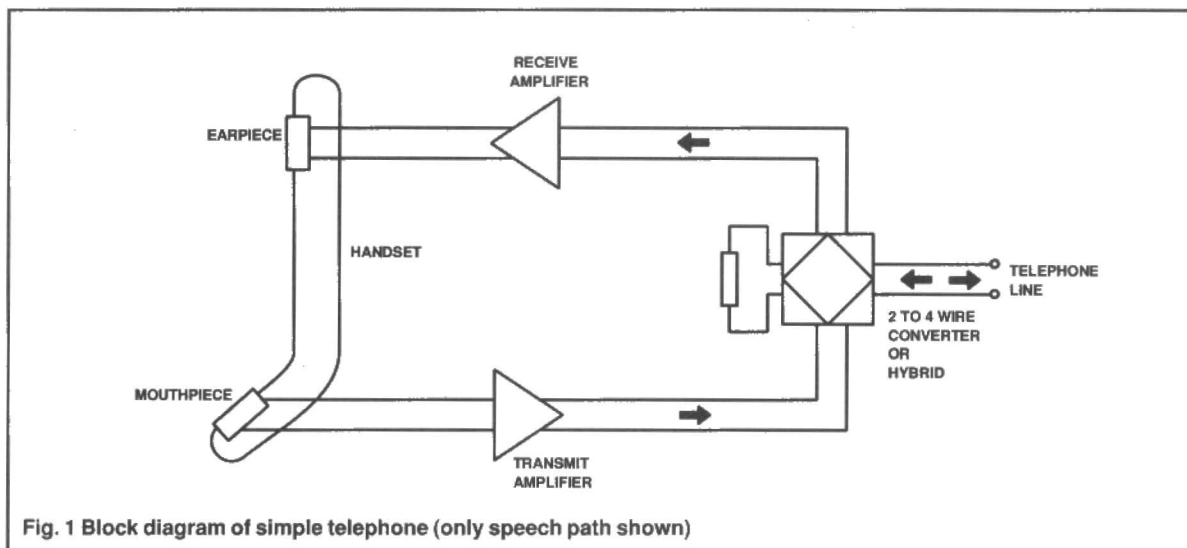
Fig. 1 Block diagram of simple telephone (only speech path shown)

# Look No Hands!

***How a hands-free
telephone works,
by Andy Burnham***

The hands-free telephone, also known as the loudspeaking telephone, has really taken off over the last decade and is now a part of an increasing percentage of 'feature phones' found in the high street stores.

This is partly due to the extra competition in the telephone marketplace, but is really a result of the development of low-cost hands-free telephone ICs. Hands-free circuits are also widely used in car telephones, following the legislation banning the use of handsets by the driver whilst moving.

Surprisingly, the hands-free telephone has existed, in the R+D labs, vaults and managers' offices of the Post Office since the thirties, originally consisting of three boxes and lots of valves. Through the sixties, designs progressed and the telephones found uses in places as diverse as operating theatres and prisons.

## Down to basics

So what is a hands-free telephone and how does it work? As the name suggests it is a device which allows its user to conduct a telephone conversation without holding a conventional handset. A small speaker and microphone are built into the main body of the telephone and the conversation is carried out through these.

At first glance it might seem that the designer of a hands-free telephone could simply glue an ear-piece and mouth-piece, along with the other circuits from a standard telephone into a box to make a simple device, but perhaps the best way to describe the evolution of the modern hands-free telephone is to show why this will not work.



FOR STABILITY:

$Gt + Gr < Lh + La$

Ie: LOOP GAIN $= \dfrac{Gt + Gr}{Lh + La} < 1$
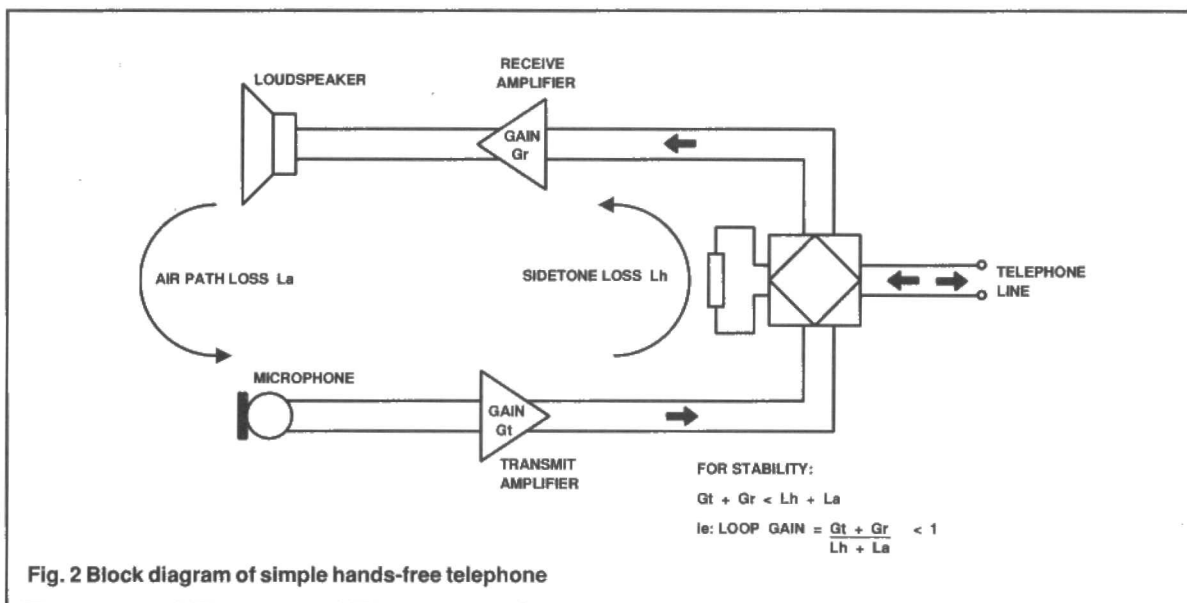
Fig. 2 Block diagram of simple hands-free telephone

A telephone ear-piece is driven by a relatively small audio signal and, indeed, older telephones do not have any active amplification in them at all, being driven directly by the audio on the line. In order to hear a speaker you need a much greater volume than is needed to drive a handset ear-piece, so a power amplifier of some sort is required. Also, as the user is speaking a few feet from the microphone, rather than

is to reduce the gain somewhere around the loop so that the overall loop-gain is less than one and feedback will be unable to build up.

The easiest way to do this is to either turn down the speaker volume, or make the microphone less sensitive, until the howl dies away, but you will either not be able to hear the person at the other end, or they will not be able to hear you!
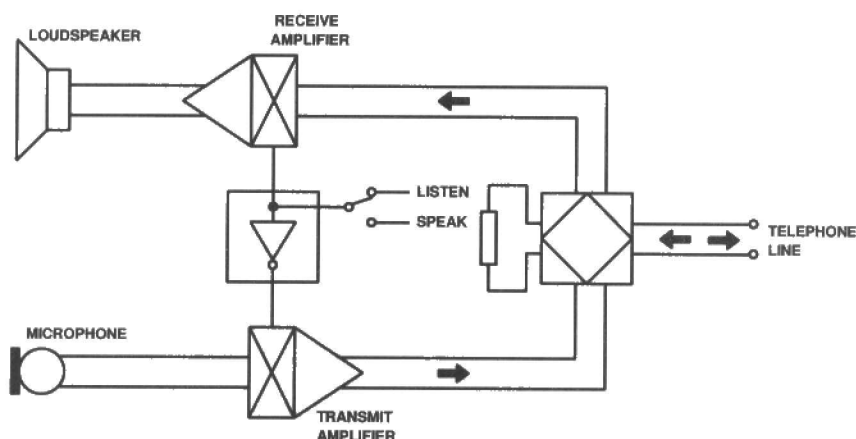
Fig. 3 Hands-free telephone with switchable attenuation

a few inches as with a handset mouthpiece, so the microphone and amplifier need a much greater sensitivity.

## Two wires meet four wires

In its most basic form, a telephone line consists of just two wires, down which all the information must be carried. The problem with a two wire line is that the speech from the distant end has your own speech superimposed on it, as both signals have to be carried on the same pair of wires. We want to separate them out (to four wires) so that we can connect our handset and the circuit to do this is known as a two to four wire converter, or hybrid. Cancelling the local speech from the distant signal is an old telecommunications chestnut and can be tackled with varying degrees of success (and complexity) with components ranging from transformers, or op-amps, to adaptive filters and Digital Signal Processor chips. Assuming our telephone will use one of the simpler (and cheaper) methods we can only expect limited success.

What we get from the output of the 2-4 wire converter still has an appreciable amount of local speech, which is why you hear yourself when you speak or blow into a telephone handset and is known as sidetone. When using a telephone handset this sidetone is useful, as it gives an indication to the user that the handset works.

## Banshee howls

In our hands-free telephone there is an acoustic path for the sound from the speaker to the microphone, both inside and outside the case. Couple this acoustic path with the increased transmit and receive gains, as well as the leak of sidetone from the transmit to receive path (Figure 2) and the result will undoubtedly be a deafening screech of feedback. The only way to get rid of this and make the telephone usable
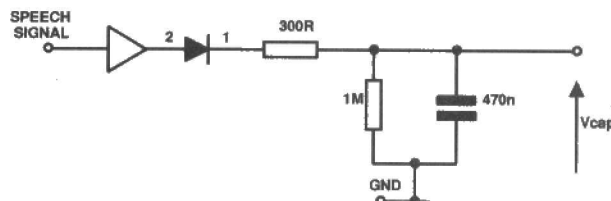


Fig. 4 A simple peak detector

## Add a switch

So, imagine having a switch marked 'Talk' and 'Listen' (Figure 3). In the 'Talk' position the speaker volume is low and the microphone sensitivity high, so that you can talk to the caller and in the 'Listen' position the speaker volume is high and the microphone sensitivity low, so you can hear the other person. All you have to do now is switch the switch to 'Talk' when you want to speak and to 'Listen' when you want to hear the other person. Of course this is very tedious so what we need is some clever electronics to do the switching for us and this is exactly what you can now buy on a chip, in the form of the hands-free telephone IC.

What this does is switch in an attenuator into either the transmit or receive path of the telephone. The attenuator for each cuts the level by the same value and around 50dB is found to work best in practice.

You now need a way of deciding which way to set the switch. The obvious way is to switch so that whichever person is speaking can be heard and to do this you need two peak-detector circuits to 'listen' to the volume level coming from the near and far ends of the line.

A simple peak detector circuit (Figure 4) consists of a diode feeding into a capacitor via a resistor. When amplified speech is fed into the diode, it conducts for positive going
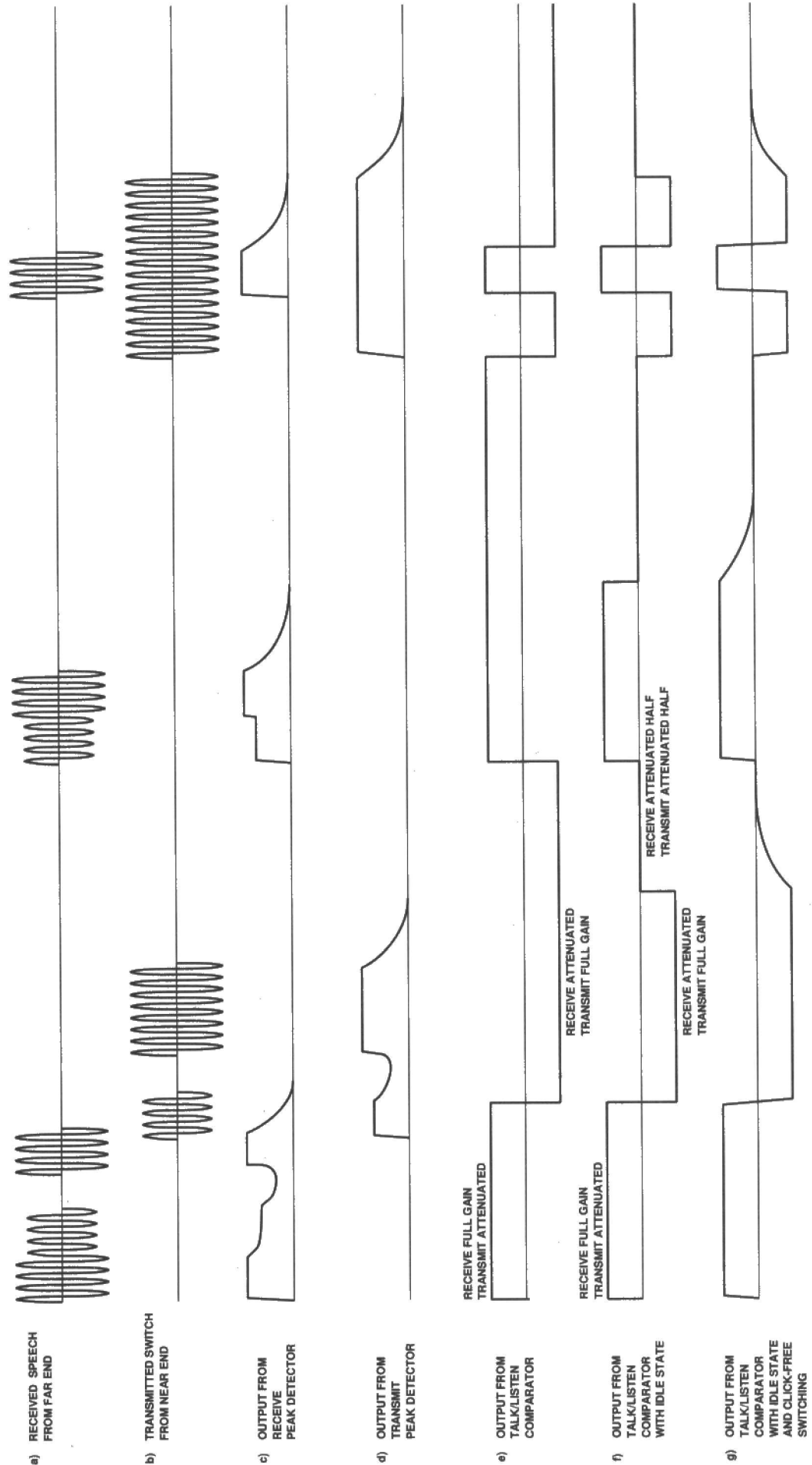
Fig. 5 Hands-free IC switching waveforms

a) RECEIVED SPEECH
FROM FAR END

b) TRANSMITTED SWITCH
FROM NEAR END

c) OUTPUT FROM
RECEIVE
PEAK DETECTOR

d) OUTPUT FROM
TRANSMIT
PEAK DETECTOR

e) OUTPUT FROM
TALK/LISTEN
COMPARATOR

RECEIVE FULL GAIN
TRANSMIT ATTENUATED

RECEIVE ATTENUATED
TRANSMIT FULL GAIN

f) OUTPUT FROM
TALK/LISTEN
COMPARATOR
WITH IDLE STATE

RECEIVE FULL GAIN
TRANSMIT ATTENUATED

RECEIVE ATTENUATED
TRANSMIT FULL GAIN

g) OUTPUT FROM
TALK/LISTEN
COMPARATOR
WITH IDLE STATE
AND CLICK-FREE
SWITCHING

RECEIVE ATTENUATED HALF
TRANSMIT ATTENUATED HALF

peaks of the speech and these flow via the resistor into the capacitor. The capacitor is charged up quickly via the 300R resistor and thus responds almost immediately to a burst of speech (Figure 5), giving an increase in voltage. (The time constant of 300R and 470n is R x C = 0.14ms)

When the speech level drops, the capacitor starts to discharge through the 1MR resistor and ramps slowly back down to zero as discharging capacitors do. (Time constant of 1Mohm and 470n capacitor is about half a second.)

So, with two of these circuits we can examine the voltages on the storage capacitors (with a comparator), decide which end is speaking and switch appropriately.

## The Switching Waveforms

Figures 5a-e show the various waveforms that control the switching of a simple hands-free telephone.

What happens if both people speak at the same time? Well, the comparator will decide between the relative volumes at each end, so the line will go to whoever shouts loudest!

Problems with this simple circuit start when you consider what will happen when neither person speaks. The comparator will still choose whichever end of the line is loudest and the result can be random switching between transmit and receive, due to noise at each end. This is known as hunting and is highly annoying to listen to.

The first refinement to be added to hands-free circuits is the addition of a third position for the switch, known as 'Idle', which is selected when neither person is detected as speaking.

This switches both the transmit and receive attenuators to half (about 25dB), so that the circuit is stable and still does not howl. As soon as either person speaks, the circuit switches to transmit or receive appropriately (the waveform that is generated and fed to the attenuators is shown in Figure 5f, the speech signals are again in Figure 5a and 5b).

## Switching Problems

Look closely at the speech waveforms in Figure 5a-d and where the IC decides to switch from Receive to Transmit, Figure 5e-g, and you can see a problem which is common to all hands-free telephone circuits.

If the caller at the far end has been talking and stops and the user (near end) immediately starts to talk, the first syllable or even the first whole word can be lost if the peak detector capacitor is too large. On the diagram the first word spoken by the user is lost and is not sent down the line to the far end, as the hands-free IC is still in the receive mode.

The voltages on the peak detector capacitors only start to discharge when speech stops. If the voltage falls too slowly and the caller is speaking quietly, then the comparator will not switch immediately because the voltage on the receive level capacitor is still higher.

The obvious solution is to reduce the values of the speech level capacitors, so that they discharge more quickly at the end of a word. If, however, the designer reduces the capacitor value too much the voltage will drop in between words in the middle of a sentence and the circuit can start to switch back and forth spuriously while one end is still speaking. This causes the speech to be broken up as in the old joke where the stand-up comic pretends that his microphone is working intermi..ant..y!

Figure 5c shows how the voltage on the peak detector

capacitor drops in between words. The choice of value for these capacitors is therefore necessarily a compromise between fast switching between near and far end when the other person starts talking, coupled with more chance of spurious switching; or a slower response time with less spurious switching.

When the hands-free circuit decides to switch from one state to another, the most basic design will click, caused by the instantaneous switching action.

Another refinement, shown in Figure 5g, is to make the transition between transmit, receive and idle a smooth ramp to get rid of the click and make the switching less noticeable. This involves replacing the switches in the hands-free telephone IC with voltage controlled attenuators, increasing the complexity and cost of the chip. This feature is found on the latest generation of hands-free ICs.

## Noise Memory

Hands-free telephones do not work reliably when either the user or the caller is in a noisy environment. Looking at Figure 5, you cannot tell whether the bursts of signal are speech or noise and neither can a rather less intelligent set of comparators.

The presence of continuous background noise can make the IC think that one end is permanently speaking and the circuit will be forced into one state, preventing you or the caller from breaking through and being heard.

The worst possible case, for example, happens when two people in the same building are both having a conversation on their hands-free telephones and Concorde flies overhead. The noise will force both hands-free circuits into transmit mode and neither person will be able to hear the other.

In an attempt to improve operation in a noisy environment, the more sophisticated hands-free ICs use a circuit called a noise memory. This works in a similar way to the speech peak detector, but in reverse (Figure 7). A continuous signal fed into it will slowly increase the charge stored in a capacitor and the voltage will rise, but as soon as the signal disappears, the capacitor is immediately discharged.

Even the fastest speaker has to pause for breath sometimes and these gaps reset the capacitor voltage, so that on average the voltage stays near zero. Continuous noise will charge the capacitor right up and this voltage increase adjusts the switching threshold of the comparator, preventing the circuit locking into one state. Some ICs have a noise memory on just the transmit path from the microphone and others have one on the receive path as well.

A further refinement just beginning to appear on the latest hands-free ICs, is the signal compressor (or AGC) on both the transmit and receive paths. This smooths out the level of the speech from each end, ensuring that both are at approximately the same level for good switching from one speaker to the other. When compressors are used, a noise memory circuit is essential for both transmit and receive paths, as the unfortunate side-effect of compressors is that they bring up the level in between bursts of speech, thus increasing the background noise fed to the peak detectors.

## Practical Circuits

One of the best hands-free ICs currently available is the TDA7540 from SGS-Thomson. This has all the features described above and switches very cleanly, even if the users are talking at different levels (thanks to the compressors) or
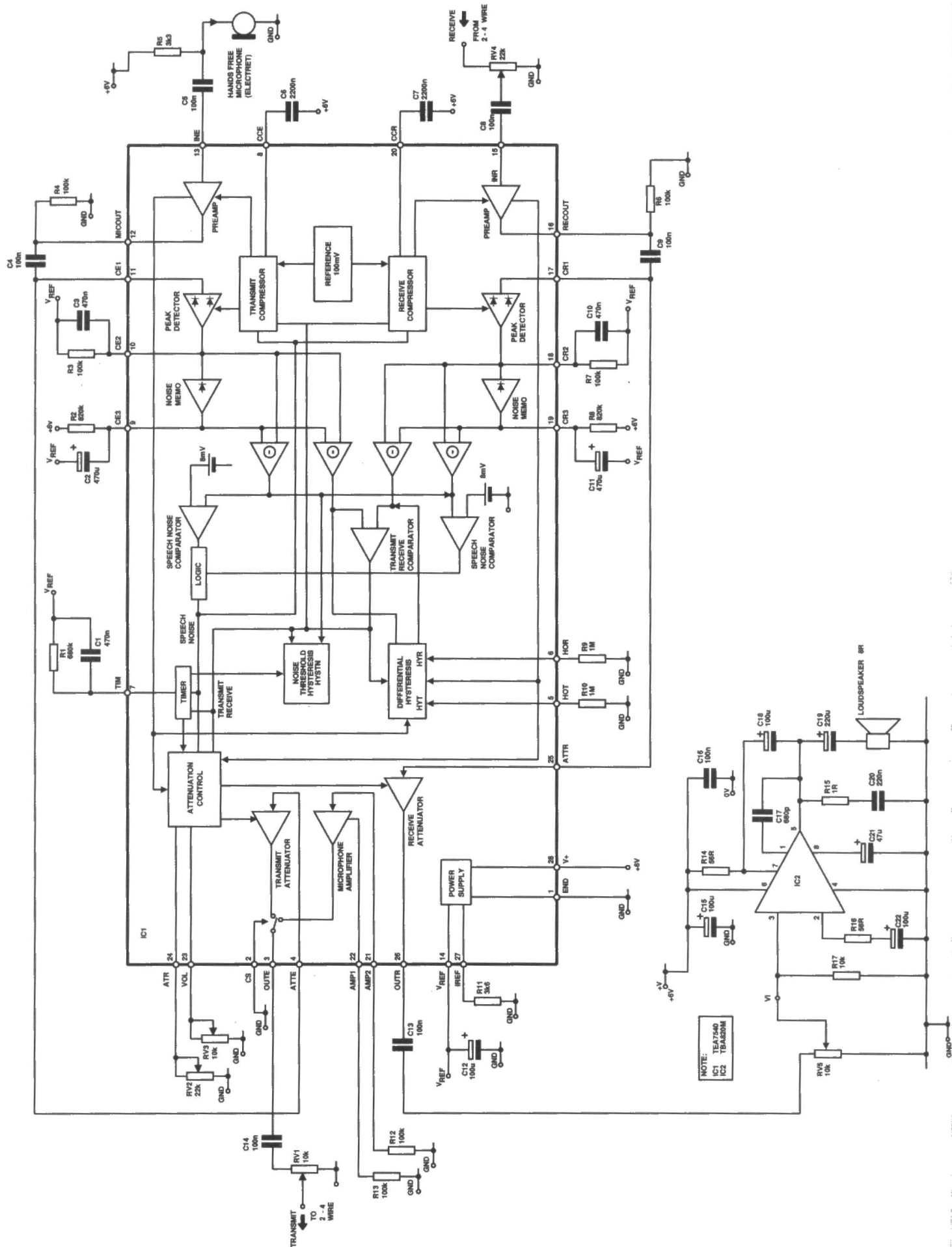
Fig. 6 TEA7540 application circuit

in a fairly noisy environment (thanks to the noise memories), but even this chip cannot cope with Hoovering or Concorde!

Other commonly used ICs are the MC34018P (RS 655-098) and MC34118P (RS 655-105), which are available from the RS catalogue. A circuit using the TDA7540 is shown in Figure 6.

## Circuit Description

The components that do most of the important work outside the IC are the Rs and Cs that set the time constants. The combination of values chosen is very subjective, so do not be afraid to tweak the values given here up or down a little - it's the best way to find out how all the timing components affect the operation of the circuit.

The fastest time constants are the peak detectors that sense the speech level on the Transmit and Receive channels to control the voice switching. These are controlled by the values of R3 and C3 (Transmit) and R7/C10 (Receive); giving a time constant of 470n x 100k=47ms. Slow acting time constants control the noise memory circuits. These are R2 and C2 (Transmit) and R8/C11 (Receive). The time constant here is theoretically 70μ x 820k=385s, although resistances inside the chip act to discharge C2 and C11 rather faster.

Two more time constants are set by capacitors C6 and C7, which are paired with on-chip resistors. These control the fast attack/slow decay times of the compressors and are optimised to respond quickly to changes in speech level so that the speaker's voice is not lost when he or she moves away
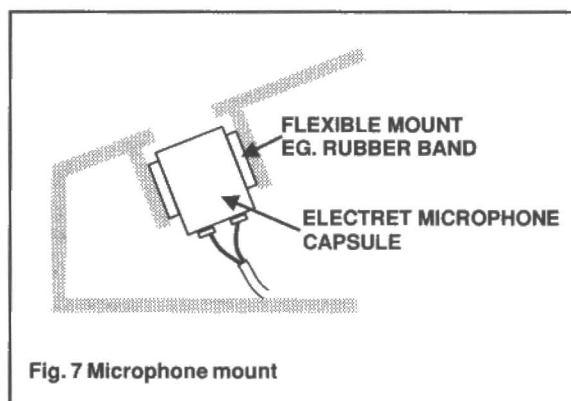


**Fig. 7 Microphone mount**

from the microphone. The disadvantage of making the compressors operate fiercely like this is that the background noise is increased in between bursts of speech, but this is usually not heard, since by the time the background noise has
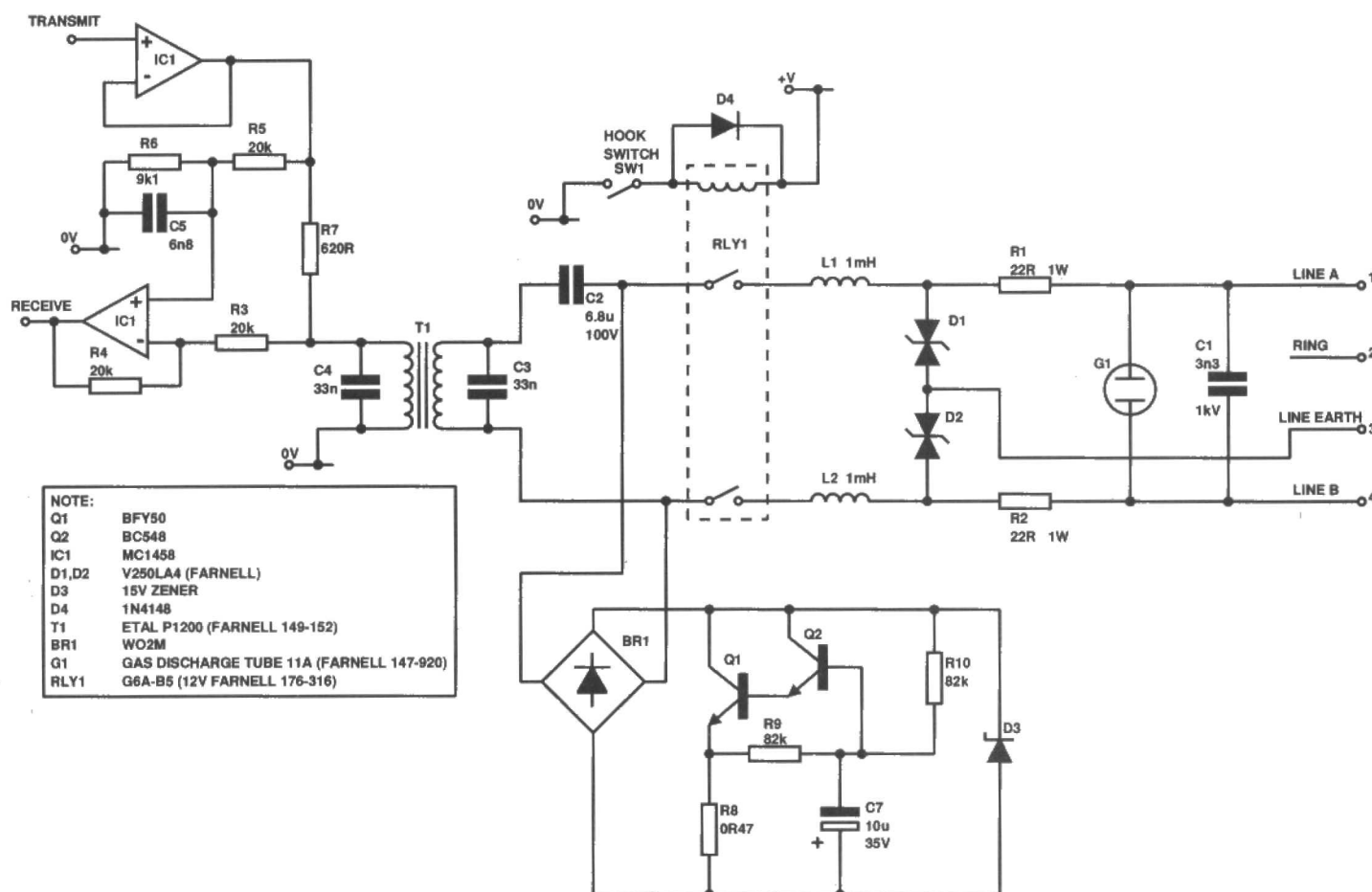


**Fig. 8 Practical telephone line interface with full surge protection**

NOTE:
| | |
|---|---|
| Q1 | BFY50 |
| Q2 | BC548 |
| IC1 | MC1458 |
| D1,D2 | V250LA4 (FARNELL) |
| D3 | 15V ZENER |
| D4 | 1N4148 |
| T1 | ETAL P1200 (FARNELL 149-152) |
| BR1 | WO2M |
| G1 | GAS DISCHARGE TUBE 11A (FARNELL 147-920) |
| RLY1 | G6A-B5 (12V FARNELL 176-316) |

increased significantly the IC will have switched into Idle mode, attenuating the channel.

The final time constant is made up of R1 and C1, which controls the speed that the attenuators cross-fade from Transmit to Receive and vice-versa. This time constant is set to $470n \times 680k = 0.32s$.

R9 and R10 control the hysteresis between Transmit and Receive modes, 1M gives plenty of hysteresis so that once the circuit has switched mode it won't jump back without a good reason (i.e. lots more volume on the attenuated channel).

RV2 controls the amount that the attenuated channel is dipped and is adjusted to give the minimum necessary to prevent howling. The less attenuation used the less obvious the switching is, but very good acoustic isolation is needed to be able to decrease the attenuation by much.

RV3 is to allow the user to control the volume of the loudspeaker. RV4 sets the level that audio from the line is fed into the receive compressor. This input is at mic level, so no more than about 10mV should normally be fed into it, otherwise the compressor will spend most of its time at minimum gain and will not be able to reduce the gain any further. RV5 is a preset that sets the maximum volume, as having the loudspeaker too loud will prevent the hands-free circuit from working.

The IC is designed to run from a single 6V rail, so it needs to generate its own middle rail at 3V, to act as a ground reference for the internal op-amps. This rail is smoothed by C12.

All the audio signals are referenced to the middle rail so AC coupling is needed to interface to audio that may have other DC offsets on it. C4, C5, C8, C9, C13 and C14 all provide this AC coupling. R5 provides power to the electret microphone, which is one with only two connections. Larger electret microphones sometimes provide a separate connection for the supply voltage but this is not really an advantage. U2 is a TBA 820M, although any low power audio amplifier can be used.

## Acoustic Design

The better isolated the microphone is from the loudspeaker, the higher the volume can be. The microphone should be placed as far away as possible from the loudspeaker and the microphone capsule should be snugly fitted to a panel, either using a rubber mount, or by surrounding it with foam.

It is best to fit the microphone near the front of the case, to pick up the speech from the user - normally the microphone is fitted to the top surface of the case, although the front edge is an alternative. It can even be placed underneath the case, to protect it from some of the more brutal Electrostatic Discharge (ESD) approvals tests that some European countries subject their telephones to!

The microphone should be fitted to the panel with a rubber gasket around it to prevent vibrations being transmitted through the body of the case to the microphone.

The size of the loudspeaker can be anything from 20mm to around 60mm, depending on the sort of sound quality and volume required. Using large loudspeakers causes extra problems because of the extra bass frequencies they produce, as these low frequencies are the hardest to isolate from the microphone. This is one reason to keep the loudspeaker fairly small.

In commercial hands-free telephones, the other reason is that the power required to drive larger loudspeakers (typically 1 to 3W) will be vastly more than that taken by rest of the telephone and will mean that the telephone needs a separate 6V supply, rather than being powered off the telephone line. Line powering limits the power for the loudspeaker to around 50mW - not very loud by any stretch of the imagination!

## Acoustic problems

When the loudspeaker is set too loud, the microphone picks up too much of the sound from the far end of the line. The result of this is that a burst of speech coming in from the far end will switch the IC to receive (as it should) so that the speech can be heard. However, this speech is almost immediately picked up in the microphone and the poor thing cannot tell the difference between this sound and the local voice it should be listening for. The result is that the level on the microphone makes the IC switch back into Transmit, silencing the loudspeaker and only tiny chunks of the beginnings of words are heard from the far end.

As you can see, when the hands-free telephone case allows the microphone to pick up too much vibration from the speaker, the volume of the speaker must be lower than it could be with good acoustic isolation.

## Power supply

Commercial hands-free telephones tend to be powered from the telephone line, but this severely limits the performance, particularly the output power of the loudspeaker. An experimental hands-free telephone built around the circuit shown should have its own DC supply of 6V, preferably a boxed supply from something like an answering machine or modem that has BABT approval.

## Line Interface

Most hands-free ICs, including the TDA7540 have four-wire interfaces, that is, separate inputs and outputs. In order to connect these to a telephone line, a 2-4 wire converter or hybrid is needed, along with circuits to isolate and protect the hands-free telephone from possible surges on the line.

Remember that connecting home-made, non- BABT approved, devices to the telephone line can lead to prosecution. Probably the best way to connect to the line is to use the insides from a telephone with a broken case, or buy a cheap and simple BABT approved one-piece telephone for around ten pounds. Disconnect the ear-piece and connect the wires to the receive input of the hands-free circuit.

Similarly, you should connect the transmit output to where the microphone connection was, with RV1 kept low enough so as not to overload the telephone's microphone amplifier.

The entire hands-free telephone should be boxed so that the user cannot touch any metal parts, to protect against possible surges on the line.

Figure 8 shows the circuit of a well protected and isolated telephone line interface. All of the important components on the hot (non-isolated) side of the line have individually passed the BS6301 safety test which means that they are safe to design into circuits that connect to the public switched telephone network. This means that the circuit itself should pass the BS6301 safety approvals test, which is the next best thing to having passed BABT approval.

### Reviewed by
### Paul Stenning

The two packages reviewed here, from Seetrax, are integrated, schematic PCB design CAD systems for IBM PC compatible computers - Ranger 1 is the low cost entry level package intended primarily for home use, while Ranger 2 is a mid-level package for more professional use. I have used these new systems to design the PCBs for a current project, so I've been able to give them a thorough testing in the course of some serious work. The main advantage of the packages over many other low cost products is that they offer Schematic Capture - that is, the connections made in the schematic (circuit diagram) are used in the PCB design, ensuring correct connectivity.
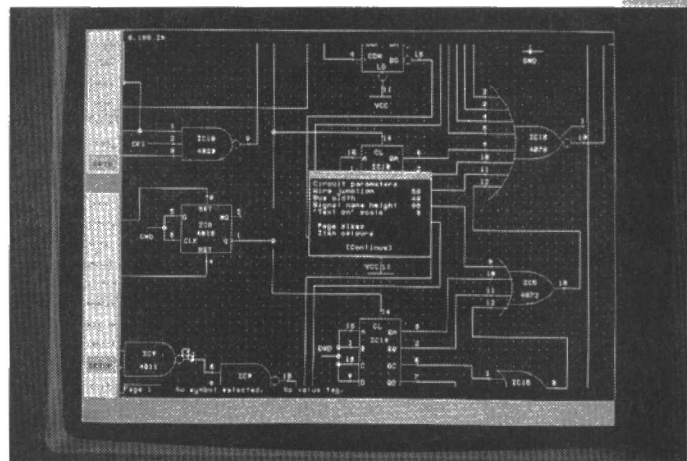


Left: Ranger 2 Schematic Editor

Bottom Left: Ranger 2 Component Placement Editor

# Seetrax Ranger 1 & 2

## Packaging and Documentation

The packages each consist of a manual, a dongle and the disks. Surprisingly there was no box or other presentation packaging, the items were just supplied loose in a large padded envelope. The information in the manuals is extremely comprehensive with a good tutorial section, as well as a useful index. The manuals were dated 1991 and were somewhat out of date, but a large Read Me file details the changes.



## Menus and Graphical Editors

The software makes extensive use of screen menus, which are text based and clear, although not particularly elegant. A small irritation is the slightly inconsistent user interface, with some screen selections made using the mouse and others with the keyboard.

The schematic, library and artwork editors are all similar graphical editors. Selections are made using menu boxes along the left and bottom edges of the screen, leaving a large editing area on the rest of the screen. In Ranger 1, menu items are selected by merely pointing at them with the mouse, although there is a set-up option to click on the menu boxes if you prefer. In Ranger 2 the menu structure is improved and feels more professional, while some of the commonly used

options have hot keys on the keyboard which speed operation. The Job Device Editor allows you to edit any component used in the schematic and create new ones. The PCB package for each device is also chosen at this stage.

A small inconvenience is that there is no means of transferring devices directly from the main libraries into the Job Device Editor, they must first be selected using the Schematic Editor.

## Schematic Entry

The supplied libraries are not as complete as they might at first appear. While a full range of TTL and CMOS logic ICs are supplied, there were no comparators, voltage regulators or audio amplifiers and the schematic symbols are drawn inconsistently. The schematic can be spread over up to 8 pages, each of which can be up to A1 size. Entering the schematic is straightforward - devices are placed, rotated and positioned as necessary and connected up. Editing is easier with Ranger 2 as wires and components remain attached to the pointer while you move the mouse. Component values can be edited as required, and the component references can be allocated automatically or manually.

## PCB Design

The first stage in PCB design is defining the board profile (outline). With Ranger 1 this involves keying in the co-ordinates of the corners and while this may be OK for simple rectangular boards, anything more complex may have to be sketched out on paper first. Ranger 2 offers a proper graphical editor which simplifies the job.

The next stage is component placement and the editor will offer the parts used in the schematic, which can be placed, moved and rotated as required. The connections between them are shown as straight lines, and the shorter and tidier the lines, the greater the chances of success when it comes to routing. Again, this is easier with Ranger 2 as the

REVIEW

REVIEW

parts move with the mouse pointer. With Ranger 2, gate and pin swapping can be carried out at this stage, to further optimise the connection lines.

Changes made are back annotated to the schematic, which is an extremely useful and powerful feature, rarely found on products in this price band.

## Routing

Initially, all the tracks are shown going directly from point to point. Manual routing involves adding and moving corners as necessary. Sections of track can be moved from one layer to another, with the required vias added or removed automatically. This method of routing is fairly easy to use, although there can sometimes be so many unrouted tracks on the screen that it is difficult to see what you are doing. Another problem is that you cannot see the component outlines, although a way around this is to generate the silk screen before routing.

The Ranger 1 package comes with only the manual artwork editor, with an autorouter available for an extra £50. Ranger 2 is supplied with a standard autorouter which will run on any PC and a two layer rip up and retry autorouter.

The optional Ranger 1 autorouter is very similar to the standard Ranger 2 version with the exception of the copper fill facility for producing ground planes. Overall it does a reasonable job and is a good deal faster than some others I've used.

An autorouter will generally work double sided and will place many vias underneath components. This is fine if you have PTH boards professionally made, but can be a problem if you make your own double sided boards and use wire or track pins to link the sides. The autorouter can be made to work single sided but its completion rate will be fairly low. This is true for all autorouters, not just the Ranger ones, and should be considered if you are planning to buy one.

The Ranger 2 rip up and retry autorouter does a much better job than the standard router, particularly on more complex boards. The router will remove tracks which are in the way of the current route and re-route them afterwards, while there are also optimisation stages which tidy existing routes and remove any clearance violations. The net result is a much higher completion rate - indeed the router will continue until it achieves 100% routing or until you stop it.

## Checking and Plotting

Once the board is routed, it can be checked for correct connectivity and clearances. This is performed automatically and you have the option to specify the clearances required. It will also highlight any track which is not at 0, 90 or 45 degrees.

The PCB artwork and schematic diagrams can be plotted on a suitable plotter or printer - a good range of common devices is supported although there is a minor bug in the printing routine whereby an offset of 0.01in has to be specified otherwise the edge of the plot is lost. The artwork, silk screen and solder resist layers can be output to a Gerber Photoplotter, but the apertures for the photoplotter have to be set up manually and the whole process is not particularly well described in the manuals. NC drilling files can also be produced.

## Conclusion

Priced at £100, Ranger 1 is very good value for money. As far as I know it is the only product in this price bracket to offer features like schematic capture and design rule checking. It is not the prettiest software around, its user interface takes some getting used to and it's sometimes rather slow, but it gets the job done. If you can live with the niggles mentioned in this review and you're prepared to work at it, then it's probably the best you'll get for the money.

Ranger 2 is a considerably more advanced product, it is much faster and the graphical editors are greatly improved. The rip up and retry autorouter is a very useful and powerful feature if you produce boards that need it and have the hardware to run it. Ranger 2 performs a good deal better than a more expensive product (no names) I have used previously and I will be continuing to use my copy!

However, at £600 some of the problems mentioned previously may be more significant - in particular it could do with an up to date manual and better libraries to fully justify the cost.
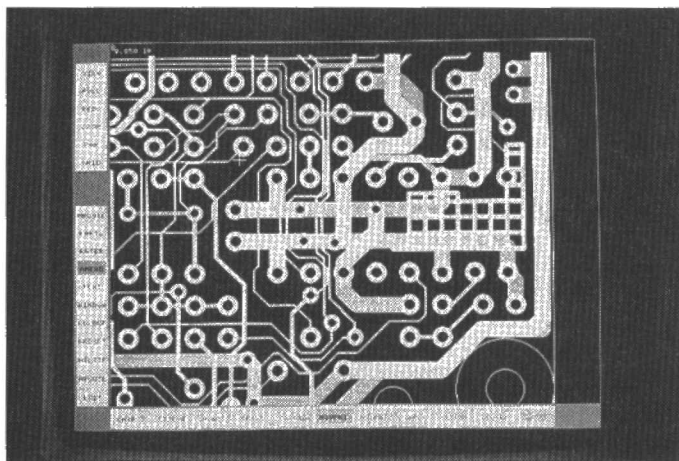


Free telephone support is available for both packages and I have used this a few times and received a friendly, helpful and knowledgeable response.

## Ordering Information
**Ranger 1 - £100**
**Ranger 1 Autorouter - £50**

**Ranger 2 - £600**
**Ranger 2 Utilities (6 layer rip up autorouter, Gerber Import & DXF Import/Export) - £350**
**All prices exclude VAT and delivery.**

The minimum system requirements for both packages are an IBM PC XT (or 100% compatible) with a 10MB Hard Disk, EGA graphics, 640K base RAM, mouse, one parallel printer port for the dongle and one serial port for the mouse or digitiser. The Ranger 2 rip up autorouter requires a 386SX or better processor and 4MB of RAM. Demonstration packs for both products are available, which contain full versions of the software, but with artwork saving and plotting disabled (Ranger 1) or limited capacity (Ranger 2).

For more information contact:- Seetrax CAE, Hinton Daubnay House, Broadway Lane, Lovedean, Hampshire, PO8 0SG.

Tel: 0705 591037, Fax: 0705 599036.

# Troubleshooting Analog Circuits by Robert A. Pease

*Reviewed by Andrew Armstrong*

This book, aimed specifically at analogue designers, is for people who can already design a working circuit configuration, but whose designs occasionally have unexpected snags (whose don't?). It will also be invaluable for people whose job it is to sort out production or testing problems on other people's designs.

It was a book I couldn't put down. Although I have been earning my living designing analogue circuits for 18 years, Bob Pease's book had a lot to tell me. The writing style is informal, without obscuring the technical points and the author has projected his personality strongly. There is a photograph of him throwing a computer from the top of the car park, with the caption "As the dust settled, I knew that computer would never lie to me again"!

Apart from the writing style, which makes learning painless, the other unique virtue of this book is that it contains a lot of information that most people just never hear about. One such item which I found particularly interesting was the test that he carried out on diodes, all purporting to be 1N4148s. He found that some makes have a switch on overshoot of 450mV at 7kHz and only 90mV at 480kHz. This would seriously affect circuits such as precision rectifiers and could present the designer with an apparently insoluble problem. This type of effect is not documented in any data sheets, nor is it contained in SPICE component models (if you go in for computer simulation).

Bob Pease does not like computer simulation. It can tell you what you should have known anyway about the normal functioning of a circuit and it can confirm some points which would otherwise have needed big equations to check, but after all the simulations, the real prototype does what it pleases.
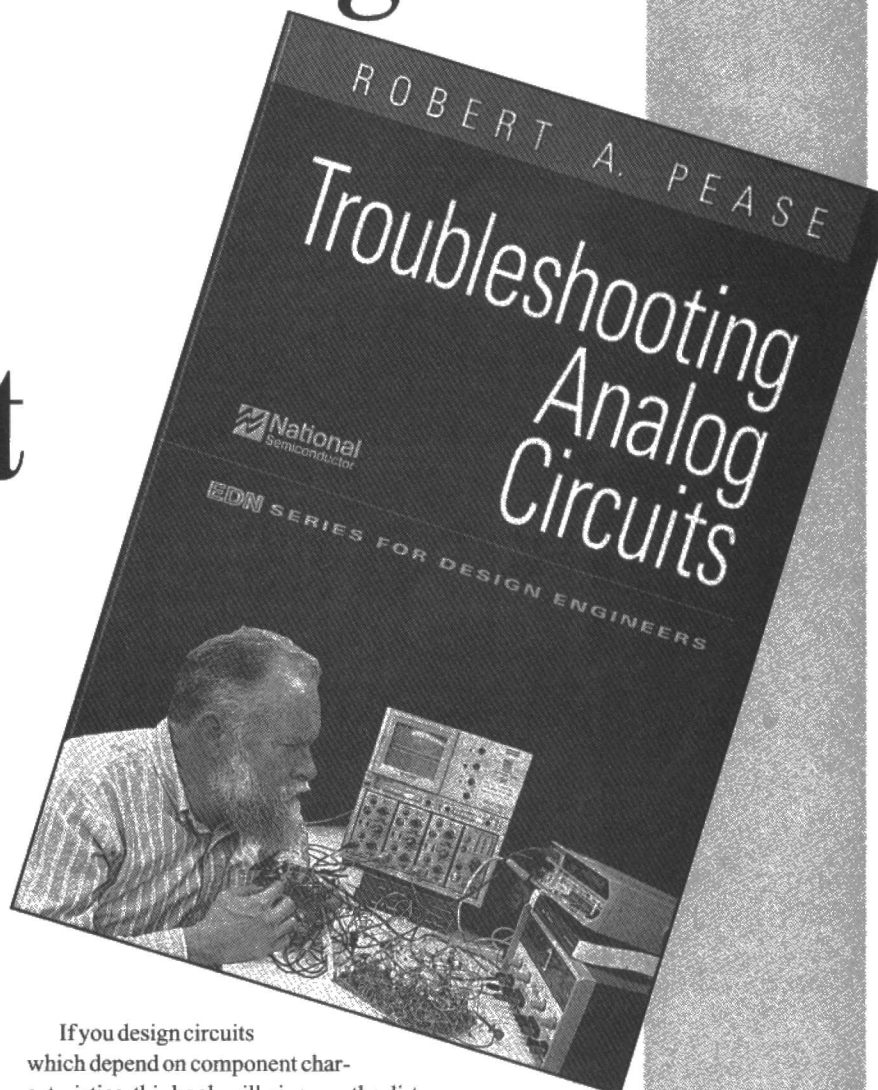
If you design circuits which depend on component characteristics, this book will give you the dirt on diodes, capacitors, resistors, inductors and many types of linear ICs. It also covers circuit layout, test equipment and the use thereof (and how to avoid it telling you porkies).

It is probably easier to define this excellent book by what it does not cover. I quote: "Digital computers: To avoid making unpleasant comments, I will simply say that I hope somebody else writes a good book on troubleshooting these. Software: No comment."

The book doesn't cover digital circuit troubleshooting as such, but some items are very relevant. For example, something which very few people seem to realise, is that if you decouple the power supply for each digital IC, the capacitors and lengths of track can form resonant circuits. What do you do about it? Read the book.

I cannot put it too strongly - if you do any serious analogue design, you want this book.

**BOOK REVIEW**

# Switch Channel for Radio Control
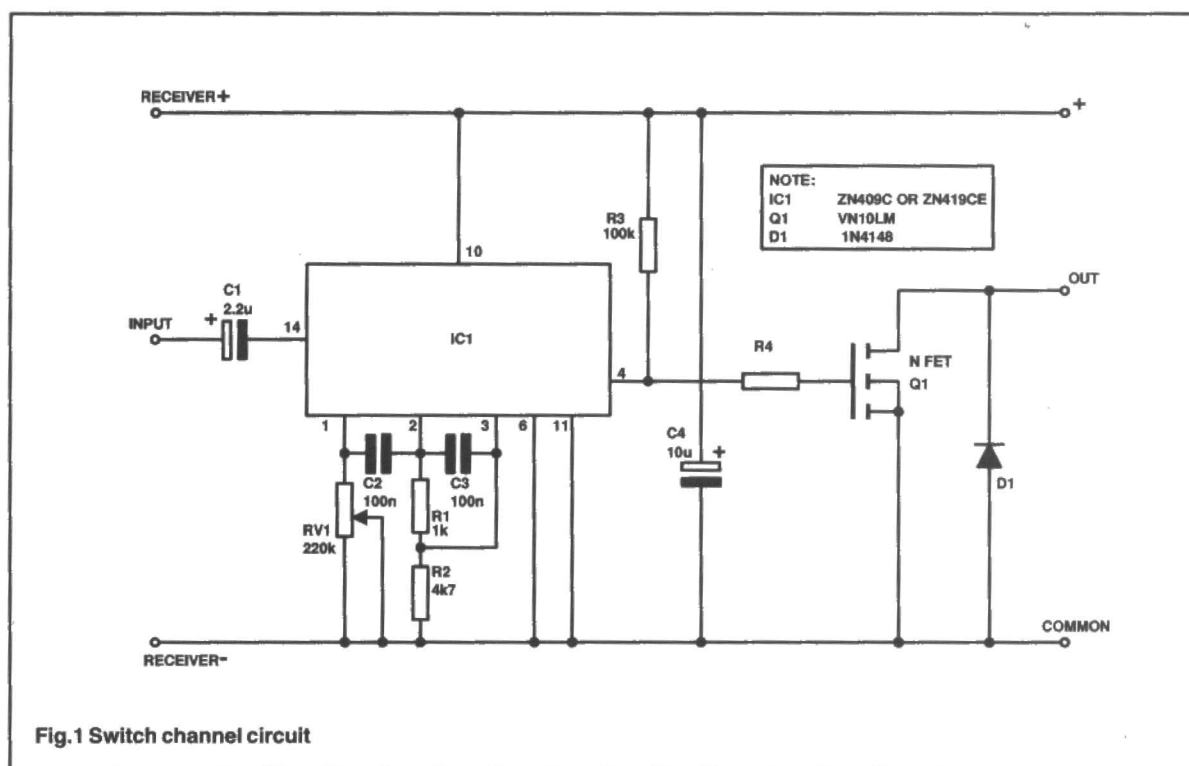


**Fig.1 Switch channel circuit**

NOTE:
IC1    ZN409C OR ZN419CE
Q1    VN10LM
D1    1N4148

*The third and final part in our radio control series by A. Craig Talbot*

**M**ost radio control operations require a proportional movement of some kind, so the majority of the available equipment was designed to do just that. Occasionally, however, you may only want a light switched on and off and it was for that very reason that this circuit was designed. I could not afford the space and cost of a servo and a mechanical micro switch just to put a light on.

The finished unit is postage stamp size and capable of switching a bulb of any size that is suitable for a model (300mA). At 12V and 300mA, this produces 3.6W, almost a Search lamp on a mere model! The circuit uses the ZN409CE IC and is much the same as the reversing part of a speed controller, omitting all the parts not required for this function. In fact I think one could say its about as simple as an IC circuit can get. With this Radio Control Switch you can switch just about whatever you want. By taking the two output wires to a relay you could switch high current and high voltage, driving an efficient small motor such as those you can get from an old cassette tape recorder, for instance. You could reduce the speed with the old capstan pulley wheel and

drive a model radar scanning head for a boat. You can also use it to drive sound making circuits and amplifiers to give your model that different sound. On that note we had better go on to the brief description and then construction, which is just as simple.

## The Circuit

Not a lot to be said here. The forward/reverse output of IC1 (pin 4) is used to drive the small powerfet via R4, a 100k pull-up resistor. RV1 adjusts the centre stick position so that as the stick passes through the centre of its travel the switch channel will switch from on to off, or off to on, depending on direction. Things like pulse expansion and deadspace adjustment are not needed here, so apart from C2, RV1, R1 and R2 the timing components, C4, the power rail decoupler, C3, RF decoupler and the back EMF protection diode, D1, that's it! Strictly speaking R3 could be replaced by a link, but it will protect the powerfet gate if R1 should go short circuit for any reason, a solder bridge, for instance.

## Construction

Take care when handling the MOS device FET1, as this component is sensitive to damage by static electricity. Do not touch its leads. Before mounting any components on the board, a link wire needs to be fitted. This link is clearly

marked on the component layout, Figure 2. It is fitted under IC1, which explains why it should be fitted first. A piece of component lead wire (resistor or diode) is the best to use. I will say again, be careful with the powerfet, no unnecessary handling. Just fit all the components as in Figure 2. The input lead (a servo lead) to match your radio control receiver is fitted according to Figure 3, but this should be clear from the drawing.
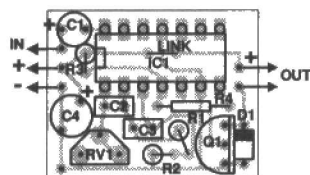


**Fig.2 Component overlay**

Now it gets interesting because you have to decide if you want to drive a small bulb or other load from the receiver supply or the drive supply, see Figure 3. If you wish to use the receiver battery (this is the easiest option and is ideal for testing), then connect a pair of twisted wires, one to the +ve connection (on the right of the board, see Figure 2), the other to the output connection. The other ends go to your bulb which must be somewhere between 4 and 6V and less than 100mA. If a larger bulb, or a horn or in fact a small motor, is to be driven then one wire should be taken from the output to whatever load you are driving and the other side of your load should go to the drive battery +ve connection. In this case the Drive battery -ve will have to be connected to the COMM (common) connection point on the lower left of the PCB.

That's it! Now to test.

## Testing

Whichever option you have decided on for the output, a bulb from the receiver battery is the best to test with. First plug the input lead into your receiver and switch on both transmitter and receiver. You then have to adjust RVl to set the switch over point to the position that suits you on your stick for the appropriate channel. When you can switch off and on to your satisfaction a small blob of paint or nail varnish can be applied to the pot.

An absolute doddle this Electronics, isn't it? By the way, if you decide to drive a small motor off this unit, use a servo motor running a very light load. Only half an Amp of current is allowed, that's the absolute maximum. Any motor used should have a couple of 10n ceramic capacitors fitted between each brush and the case of the motor. Worst case noise will require an additional 100n capacitor fitted across the motor and the motor leads fed through a couple of 1A RF chokes. See Figure 4 and the Additional components in the parts list.

## PARTS LIST

**RESISTORS**
| | |
|---|---|
| R1 | 1k |
| R2 | 4k7 |
| R3 | 100k |
| R4 | 1k |
| RV1,2 | 220k min vertical preset |

**CAPACITORS**
| | |
|---|---|
| C1 | 2u2/10V tant bead |
| C2,3 | 100n ceramic |
| C4 | 10u/10V tant bead |

**SEMICONDUCTORS**
| | |
|---|---|
| IC1 | ZN409CE or ZN419CE IC |
| FET1 | VN10LM POWERFET (handle with care) |
| D1 | 1N4148 |

**MISCELLANEOUS**
Servo lead see BUYLINES
Additional suppression components
For electrically noisy motors (see Figure 4)
10n low voltage Ceramic Disc Capacitors 2 off
100n low voltage Ceramic Disc Capacitors 1 off
1 Amp RF Axial Chokes 2 off
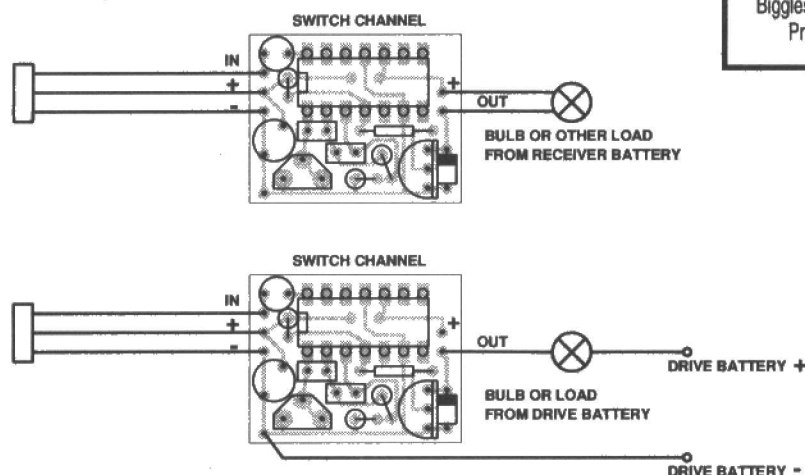
**Fig.3 External connections**
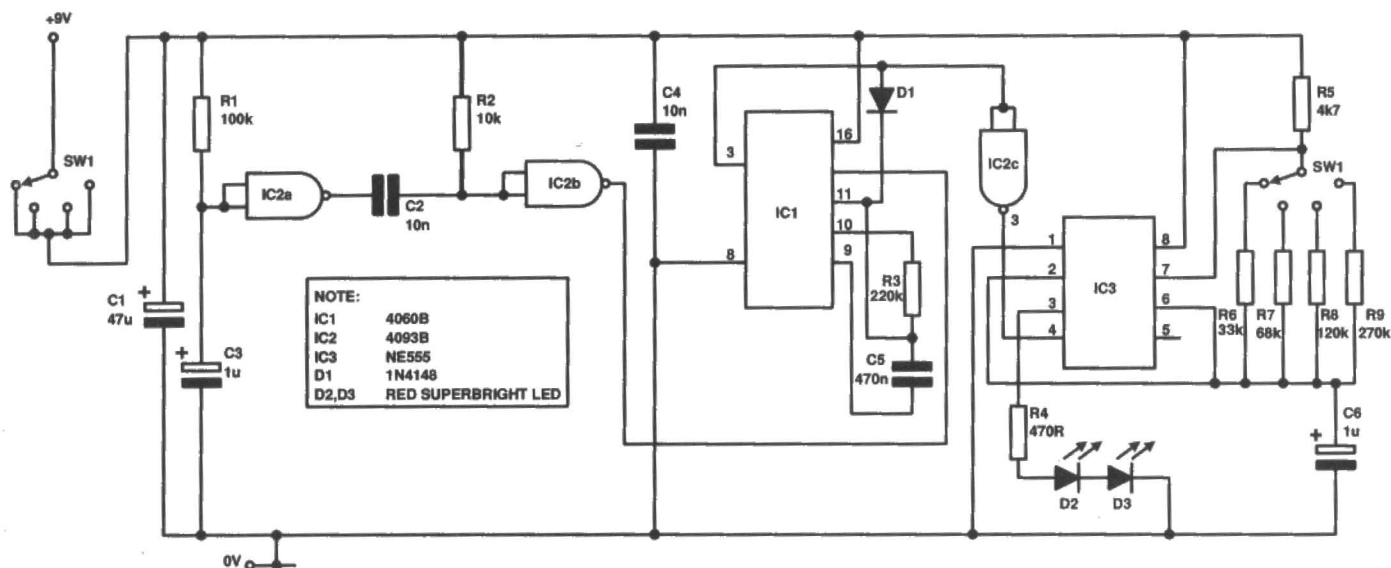
Fig.1 Circuit of Mind Trainer

NOTE:
IC1     4060B
IC2     4093B
IC3     NE555
D1      1N4148
D2,D3   RED SUPERBRIGHT LED

# Mind Trainer

## by Peter Cartwright

This interesting device is designed to induce changes of mood in it's users. In essence, it comprises an oscillator circuit and a pair of flashing lights that shine onto the subject's closed eyes, with their flash rate set to favour the emergence of some mood. Its principal merit, relative to biofeedback designs, lies in its ease of use and the fact that the user won't have to pay for the experience by looking like the victim of an electrocution experiment!

It has long been known that if electrodes are placed against the skull, a pattern of cyclic electrical activity will be observed and the frequency of this will vary with mood. The traditional biofeedback approach to creating a mood electronically employs this fact but the more recently developed approach described here works more directly. Eyes are often said by neurologists to be outstations of the brain, since the retina acts as a processor as well as a receptor. Moreover, everyday experience convinces that the eyes are the 'window on the mind' and given this, it isn't altogether surprising that a pulsing light tilts perception in strange ways. It's currently thought that moods and their associated brain waves can be altered by a light flashing at the sympathetic frequency and it is this that underlies the action of photic devices.

Brain waves are conventionally divided into four main categories - Beta, Alpha, Theta and Delta. Beta waves extend from 25Hz to 14Hz and arise with the subject wide awake and thinking. Alpha waves go from 14Hz to 7Hz and are engendered when the mind is intellectually inactive but nevertheless awake, sometimes called the meditative state. Theta waves, 7Hz to 4Hz, have been measured during periods of creative thought and Delta waves, 4Hz to 2Hz show up during sleep.

Not surprisingly, most interest is directed at alpha waves and theta waves because the benefits of meditation are well documented while most people would like to expand or realise their imagination.

## Design

For its portability and safety, a battery powered design was chosen. Cases with compartments for PP3 batteries are somewhat cheaper than other types and this dictated the dimensions.
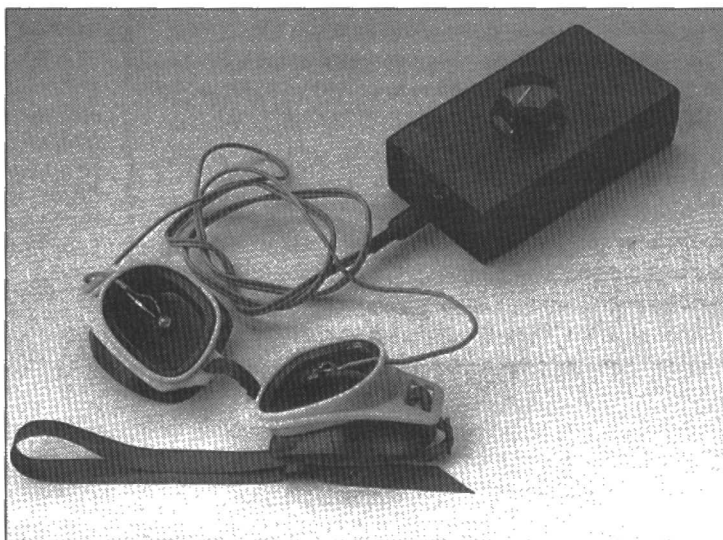
The flashing lights are undiffused superbright LEDs. They are wired in series, to provide similar brightnesses. The current consumption of the LEDs is quite modest, and readily supplied by a 555 IC, configured as an oscillator with an approximately equal mark and space.

A very useful feature is the session timer, which gives, with the selected value of components, a period of 20 minutes. At this point the flashing LEDs are switched off, although, of course, the circuit will continue to draw current. To keep the design compact, it was decided to combine the power supply switch with the frequency control. The need for calibration is obviated by four fixed frequencies, corresponding to each of the brain wave categories. Selected clockwise by the rotary switch, these are nominally set at 2.7Hz, 6Hz, 10Hz and 20Hz.

## The Circuit

To be absolutely sure that the counter in the session timer starts off at zero, the first operation on powering up will be to automatically activate the reset function. The front end of the circuit diagram consists of a pair of NAND gates with Schmitt trigger inputs, connected as inverters. The input of IC2a will initially be at 0V after switch on and its output will be high, as will be the input of IC2b. The latter's output is connected to the reset pin of IC1, which is inactive low. As C3 charges, the output of IC2a goes low which appears as a downwards spike on IC2b. This in turn produces the brief pulse that resets the counter.

The 4060B comprises an oscillator and binary counter, wired as a long duration timer. R3 and C5 determine the oscillator frequency. This

of course, can be increased or decreased by changing either R3 or C5, but it should be noted that R3 is, as shown, close to its maximum value. If you wish to extend the session to 40 minutes, say, rouhling the capacitance would be the preferred option.

The binary counter has 14 stages, the last stage having a cycle period 16384 times that of the oscillator. To make it work as a timer, the 14th stage (pin 3) is connected to the oscillator section via a diode. Thus, as the output goes high at the half cycle point, the oscillator is inhibited. Simultaneously, the output of the third inverter goes low, as does the reset pin of the 555 chip, to which it is wired. Its oscillations stop and the LEDs cease flashing.
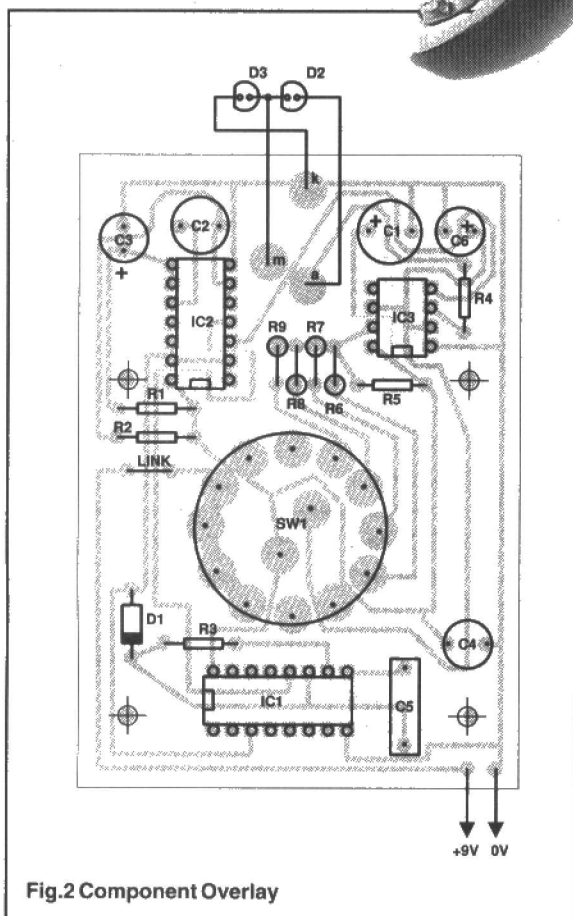


## Construction

The illustration shows swimming goggles supporting the LEDs. Eye protectors or cheap sunglasses would doubtless work too, although goggles can be adjusted for different eye spacing. The holes for the LEDs should be situated over each eye. The screened cable is threaded through a small hole in the side of the surround, coming out in front of the Perspex. Because the LEDs are wired in series, it's best if the screen of each wire is soldered together at the PCB. An alternative which may be more convenient is to connect the cable via a jack plug. The socket is a mono 3.5mm type, but with the type shown a stereo plug can be used with benefit. The tag attached to the central ring, which is free of contact, can be used as an anchor point for the screened wires.

To avoid a cats cradle of wires, the PCB is designed to accept the rotary switch directly, but before soldering, the bulbous ends of the tags need to be snipped off.

## In Use

The mind trainer should be treated with respect, which means that you should avoid its use if you are prone to epilepsy. It's also a good idea to try it out with someone else present in case of an adverse reaction. You should immediately cease using it if this happens.

The LEDs are designed to illuminate your closed eyes only - the eyelids will diffuse the light. Lying down isn't recommended as you might fall asleep, so if you are seated and comfortable, you can begin.



**Fig.2 Component Overlay**

No doubt individual reactions vary quite widely, but you will probably notice that Beta and Alpha frequencies produce psychedelic effects while Theta and Delta frequencies are perceived as flashes of light. Although no objective experiments were conducted, I can say that the lower frequencies felt relaxing and my dreams were, for a while were more colourful. I also have an interest in sculpture and after using the mind trainer at the theta frequency, a particularly resistant design knot was untied.

Whether you derive any long term benefit from it or not, if you are interested in the subject of mood alteration, this design allows an inexpensive way to explore it.
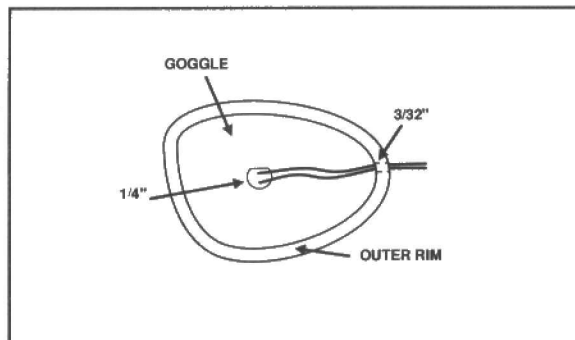




## PARTS LIST

### RESISTORS all 1/4W

| | |
|---|---|
| R1 | 100k |
| R2 | 10k |
| R3 | 220k |
| R4 | 470R |
| R5 | 4k7 |
| R6 | 33k |
| R7 | 68k |
| R8 | 120k |
| R9 | 270k |

### CAPACITORS

| | |
|---|---|
| C1 | 47u elect. radial |
| C6,3 | 1u elect. |
| C2,4 | 10n ceramic |
| C5 | 470n polyester |

### SEMICONDUCTORS

| | |
|---|---|
| D1 | 1N4148 |
| D2,3 | Red superbright LEDs |
| IC1 | 4060B |
| IC2 | 4093B |
| IC3 | NE555 |

### MISCELLANEOUS

SW1 2 pole 6 way rotary (adjustable stop)
PP3 Battery and connector
Case
Goggles
Individually screened twin screened cable
3.5 mm jack plug (stereo)
3.5 mm jack socket (mono) -
obtainable through Maplin Code FK02C.

Tobacco tins can be used for a wide variety of small projects.
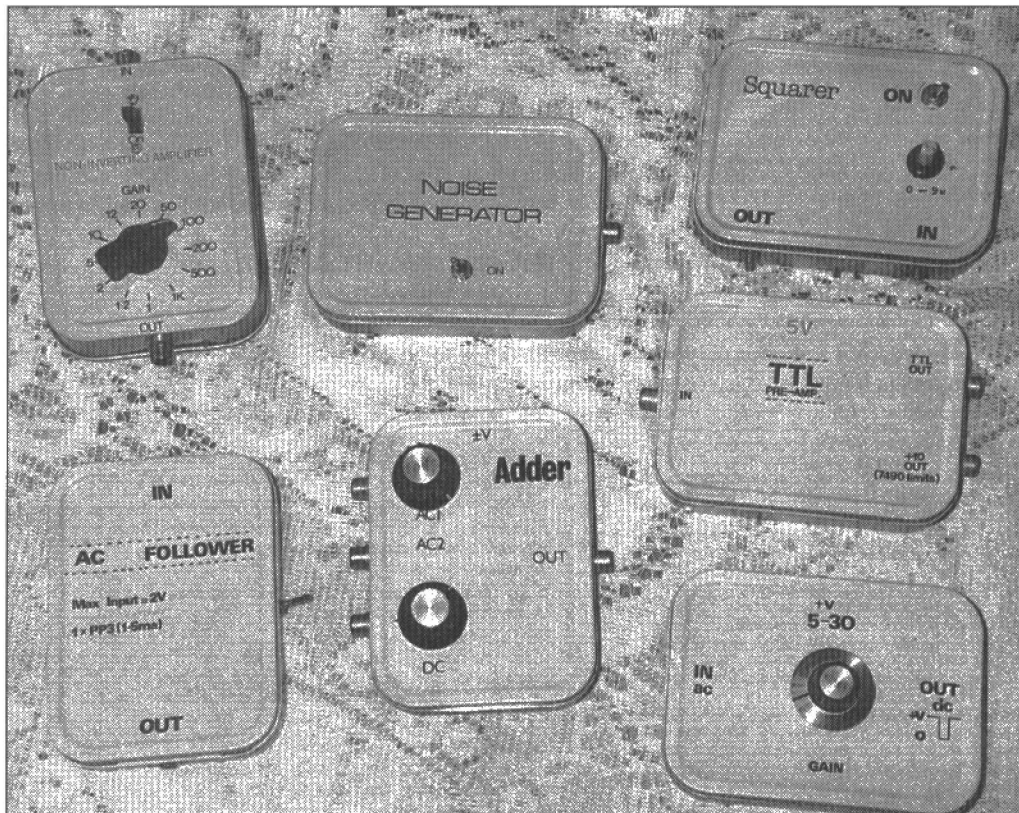
# Low Cost Cases

## by Terry Pinnell

Today's major electronic component suppliers offer some excellent ranges of project cases in all types and sizes. However, there can often be advantages to be had by improvising your own from easily available materials, rather than always buying ready-made. Perhaps the most obvious motive is to save some cash - good quality cases do not come cheap - but the do-it-yourself approach can also offer you more flexibility over the size and shape of the final unit, allow you to finish a project when you don't have the right case to hand and give you the extra satisfaction of extending your creativity and ingenuity.

Of course, you need some raw materials to start with but if, like me, you are a bit of a hoarder, you will usually have no problem finding suitable stuff in your junk box. For years I used to stockpile all sorts of domestic flotsam and jetsam and much of it has been put to good use. Disposable razors, whose plastic handles can be cut to size for handy spacers; old pens for coil formers; aerosol can tops to hold miniature loudspeakers; coffee jar lids for making chunky radio tuning knobs, and so on. Most useful of all have been a variety of things for making low cost electronic project cases.

Tobacco tins, slide-photograph holders, plastic guttering, jewellery cases, old steel punched card trays and many other items have all ended up being used in this way. Even if you have been spared this stockpiling habit and cannot look to an existing cache as a source for your cases, these sorts of things are easy enough to lay your hands and the lowly origins do not necessarily mean that such projects have a poor quality of finish, as I hope you will agree from some of the photographs.

## Tobacco Tins

Before sanity returned many years ago, I was an entrenched pipe-smoker, so it is not surprising that the humble two-ounce tobacco tin became a popular choice of mine for home-made smaller project cases. Apart from their sheer availability, they had the merit of air-tight snap-fit lids, with no screws necessary for access. They also offered RF screening and a good surface for finishing. Years after kicking the tobacco habit, when I ran short of empty tins for my projects, I wrote to one of the manufacturers and was delighted to receive a gross of tins free of charge. I reckon it will be well into the 21st Century before I run out again.

Aside from their limited size, about the only disadvantage I can think of is that working with tin is rather different to the more usual materials like plastic and aluminium. To mount your pot, switch, socket or whatever, you still use your electric drill but it doesn't so much drill the hole, as sort of gouges it out. It's then a simple matter to tidy up by tapping the sharp ends flush to the inside surface with a suitable piece
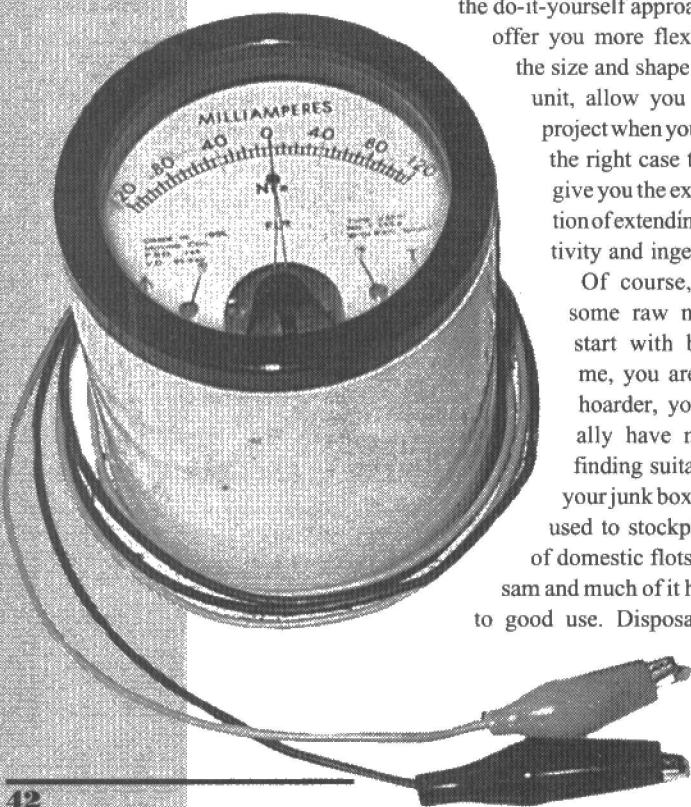
of wood and a small hammer. If the hole turns out to be too large, a suitable washer can be glued to the inner surface, with an inner diameter still large enough to take your component. Alternatively, a modest application of fast-setting epoxy glue can effectively reduce the size sufficiently.

A PP3 battery fits comfortably inside these tins and can be secured firmly in several ways. You could, for example, glue a piece of sponge (or self-adhesive window-sealing strip) to the lid in the appropriate position so that the battery is held by pressure alone. Or you could shape a small bracket out of thin tin or aluminium and fasten this to the case with a self-tapping screw or a small nut and bolt. Occasionally, it might prove more convenient to use the base rather than the lid as



the 'top'. This has the advantage that all wiring between switches, pots, sockets, etc., can be of minimal length and is fixed permanently in position. The lid, now on the bottom, is removed to gain access to the battery or presets, etc., but no wires need to be connected to it.

The dimensions of these tins are about 3.2in x 4.2in and about 1in deep, so they are naturally best suited to small pieces of test equipment, amplifiers, signal generators and the like. These might be powered from internal batteries (one or two PP3s or a few AAs or AAAs) or possibly externally from a bench supply or from the circuit under test. If a larger size is needed, then you can bolt two tins together, base to base. The two nuts and bolts in opposite corners might also conveniently be used to mount other components, such as a battery-holder bracket, a circuit board or even a miniature mains transformer.

To finish the case it is only necessary to spray the top (usually the lid) with a coat of cellulose auto-spray paint or something similar, preferably with an initial undercoat.

Various examples of the single tin version are shown in the accompanying photograph, with various configurations of pots and switches to illustrate how flexible these humble boxes can be.

## Plastic Guttering

Square section plastic guttering or ducting is an excellent material for smart-looking cases. Robust and good-looking, it can be sawn and drilled easily, cut to any length and takes transfer lettering well. There are various types available, but the sort I mainly use is made by Marley and has internal

dimensions of 2in x 2.5in. Fortunately, this means that it snugly holds a PP9 battery, which has proved ideal for a number of projects, such as kitchen timers and damp detectors, which benefit from fitting a large capacity, low-current battery that you can forget about for a few years. As shown in the photograph, the end pieces fit tightly and offer easy accessibility (although small self-tappers can be added if you have young children committed to opening anything not screwed, nailed or bolted).

A major advantage is being able to cut whatever length you need, while It is also handy that the end pieces raise the main case up a little, so that screws and nuts/bolts can be mounted underneath without needing pads to prevent damage to table tops and the like.

Provided that you have selected a white colour, when it comes to finishing you have a head start and all that's needed after adding the transfer-lettering is to spray with a suitable fixative protective varnish.
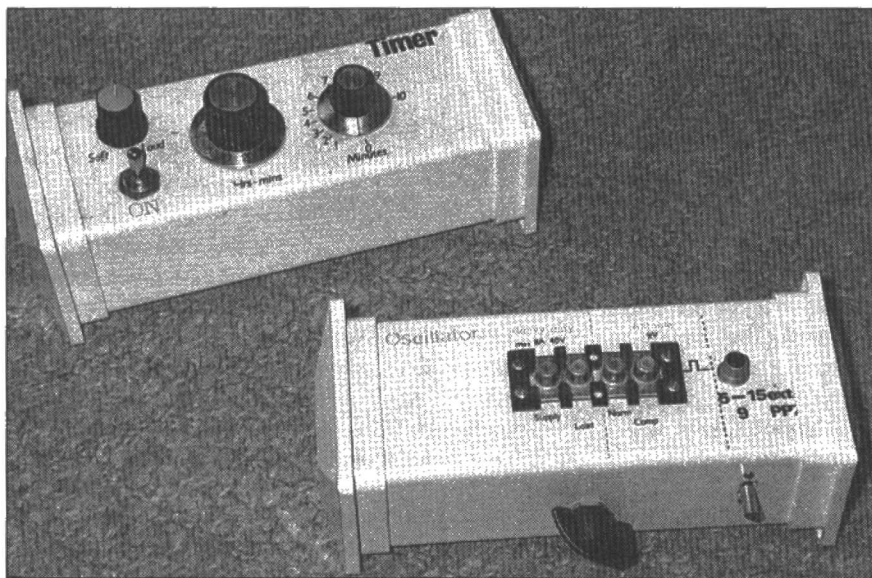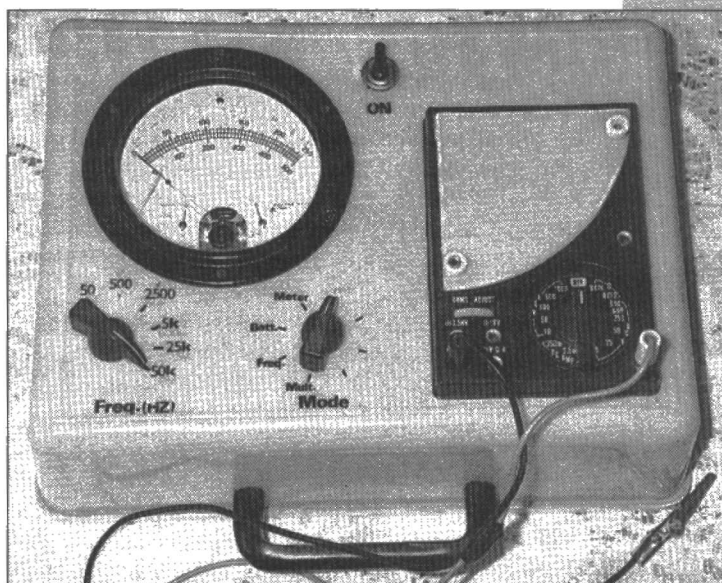
## Other Sources

As you can see, there are many other miscellaneous materials which you could use to improvise cases.

My slide days are over now (all that messing with projectors and screens was never quite worth it) but I did make good use of the spent cases. They are made of fairly brittle and lightweight plastic however, so drill pilot holes first and handle with care.



Round section ducting of the right diameter can make a neat way of holding obsolete meters cluttering up your junk box. Lids from index card holders, with the addition of a carefully cut panel, can make a cheap substitute for those expensive sloping-front cases. Some of the cases you get when you buy a watch or a piece of jewellery have always struck me as too good to discard and the flat sort can hold a

**Make sure you keep hold of all those old slide cases.**

## A Case of Good Health

Even a humble Vitamin-C tablet container can find a new purpose in life. Stripped of its painted exterior, the aluminium tube has been put into service as the ideal container for a fuse-tester. One terminal is the case itself, held in one hand, with the fuse held in the other, touching the end washer. Incidentally, this has now been in regular use for a full ten years - still with the original set of four AAA cells.

## Out to Lunch

A larger scale example is also illustrated, to make sure I have driven home the theme that virtually anything can be pressed into use. The orange plastic lunch box takes on a completely unexpected new role when converted into the housing for a versatile multimeter!

Hopefully you will realise that I'm not out to lunch, it's more a case of what comes to hand

PP3 battery and a circuit board, together with switches and shallow pots. The fancier types are useful too, but they tend to be rather light, as there is usually no battery inside and this, together with their small footprint, means that they are inclined to slide around your bench, so a few pieces of self-adhesive foam strip need to be judiciously positioned underneath to restrain them.

# Anniversary AutoMate Mixer

*Going Solo? Need to Audition? Look no further. Mike Meechan explains all.*

R udimentary talkback systems exist in all desks, regardless of type, although they are probably more complicated on broadcast desks, where the producer as well as the engineer/operator may have his or her own talkback system. Talkback allows us to communicate, usually via a console-mounted microphone, to the artists in the studio or to the outside sources on a loudspeaker and so is usually part of the post-fader foldback mix. We may also wish to use talkback to speak to each headphone foldback circuit separately or simultaneously, or perhaps to communicate with another control room (cubicle in broadcast terminology). Finally, the operator may need to speak onto tape - 'Slate' - for identification and such like.

As well as the voice identification - 'ident' - on the tape, Slate also usually places low frequency tone in the same places. This is then audible when the tape is being spooled at speed past the heads. Normal talkback systems require tandem tone injection circuits, with all places where talkback - speech - can be routed also switchable to the desk tone source(s). Tone is used to verify whether a circuit has been established or as an aid to line-up. See Figure 2 last month.

LS Cut may be implemented by a fader-backstop/Mic select switch operated muting system (as in the AutoMate) or via a system known as SLS (Studio Loudspeaker Silence), where the insertion of a jack into any mic input on the patchbay and a desk input arms the muting system. Similar systems also operate alongside cubicle monitoring speakers whenever the desk talkback mic is live. The SLS system is normally employed on broadcast desks where all console inputs, inserts, break jacks, listen jacks and outputs are balanced and available on comprehensive rack-mounted patchbays. See Figure 8 last month.

Broadcast desks use a comprehensive interlock system so that it is never possible for the talkback to be routed to the studio loudspeaker when a microphone is live. A broadcast environment is such a unique one, with its own peculiar requirements and needs, that it is worth looking briefly at some of the unique switching arrangements which exist at various points in the programme chain. In any case, the AutoMate may very well be used as part of a hospital or university campus radio set-up and I'm quite sure that those involved in such activities would term themselves broadcasters, albeit on a smaller scale!

An area of great importance is the Control Room (CTA) and from this hub originates the building 'ring main'. Conventionally, all network outputs, radio and TV, and perhaps the speaking clock, are catered for, all available for selection and monitoring via a rotary switch. There may be as few as 2 or as many as 24. The ring main outputs are also available as an integral part of the desk's main monitoring

system, being plumbed in during studio installation. There are three points of special significance: a point on the ring main which is fed from the Studio Output (not the desk output) after it has been routed to the CTA source mult; a feed of the Network output, a confidence restorer since it allows the studio to hear itself on the ring main; and Point 11 (studio output), not necessarily the same as network output since tone could be selected during rehearsal or the studio could be de-selected from the network.

When monitoring on point 12, the desk output can be heard although studio output is tone. This is because the monitoring point is taken prior to the tone injection stage.

Broadcast desks have, in essence, two different modes of operation - Rehearsal and Transmission - and these affect talkback muting and routing arrangements. Talkback will replace the desk main output and studio loudspeakers will be dimmed when in Transmission, but both facilities will be disabled when the desk is in Rehearsal. When one thinks about it more closely, the multitude of permutations possible escalates with frightening ease. See Figure 1.

Those consoles intended for use as PA or FOH (Front Of the House) mixers will have talkback arrangements of similar complexity to the broadcast type but a much reduced monitoring system, since the public address rig itself provides the main monitoring. Recording-style desks, on the other hand, normally comprise of much simpler talkback arrangements but include more complicated monitoring systems. As far as switching within a sound desk environment is concerned, the comms. side doesn't pose as many problems as the other two areas of monitoring and routing, because absolute quality and fidelity is less important with talkback.

## Monitoring

The ability to monitor a particular input signal or group of signals is probably the single most important switch-related aspect of a whole recording style mixing desk as it allows the engineer to listen to the results of his pains and labours. A complex channel-by-channel monitoring system (unlike a complex and comprehensive comms. or talkback system) is not necessary on a broadcast-style desk where Pre-Fade Level on each channel, group and output usually suffices (although the master section allows the monitoring of far more sources than a typical multitrack desk).
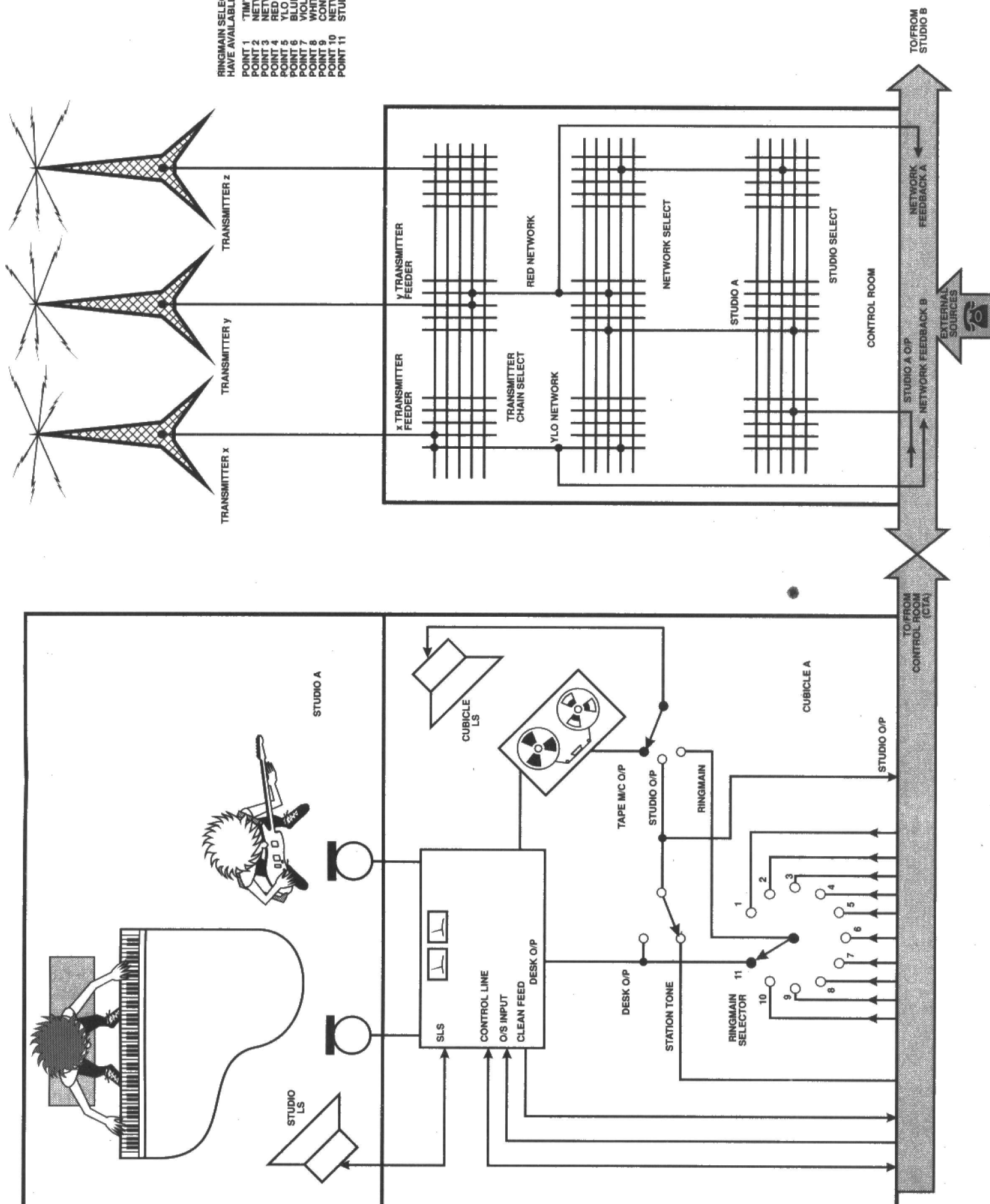
## Console Master Module Monitoring

It is normal convention for the console main monitoring and talkback controls to be housed within the master module. This holds true whether the console is a broadcast, monitoring, multitrack recording type or whatever. Figure 2 is accurate enough to be called representative of the monitoring

Fig.1 Simplified schematic of typical broadcast audio routing (microphone to transmitter)

RINGMAIN SELECTOR MAY, AS AN EXAMPLE, HAVE AVAILABLE THE FOLLOWING SOURCES:

POINT 1 'TIM' (SPEAKING CLOCK)
POINT 2 NETWORK 1 TV SOUND
POINT 3 NETWORK 2 TV SOUND
POINT 4 RED NETWORK RADIO
POINT 5 YLO NETWORK RADIO
POINT 6 BLUE NETWORK RADIO
POINT 7 VIOLET NETWORK RADIO
POINT 8 WHITE NETWORK RADIO
POINT 9 CONTROL ROOM PLUGGABLE FEED
POINT 10 NETWORK FEEDBACK
POINT 11 STUDIO OUTPUT

**Fig.2 Typical Master Module monitoring**

NOTE:
DIAGRAM SHOWS MAIN CONSOLE MONITORING WITH PROVISION FOR UP TO TWO EXTERNAL SOURCES
REAL SYSTEM MAY HAVE MANY MORE. IT WILL ALSO BE ABLE TO ACCESS ANY OR ALL OF THE AUX
MIX BUSSES. THESE HAVE BEEN OMITTED FOR CLARITY. SYSTEM IS ALSO SIMPLE PFL-ONLY, WITH
SOLO-IN-PLACE OMITTED IN THIS INSTANCE. SEPERATE SHEET FOR FULLER DETAIL OF SOLO-IN-PLACE
SWITCHING IS SHOWN, WHERE APPROPRIATE, WITH RELAYS. THIS IS FOR CONVENIENCE ONLY. FETS OR
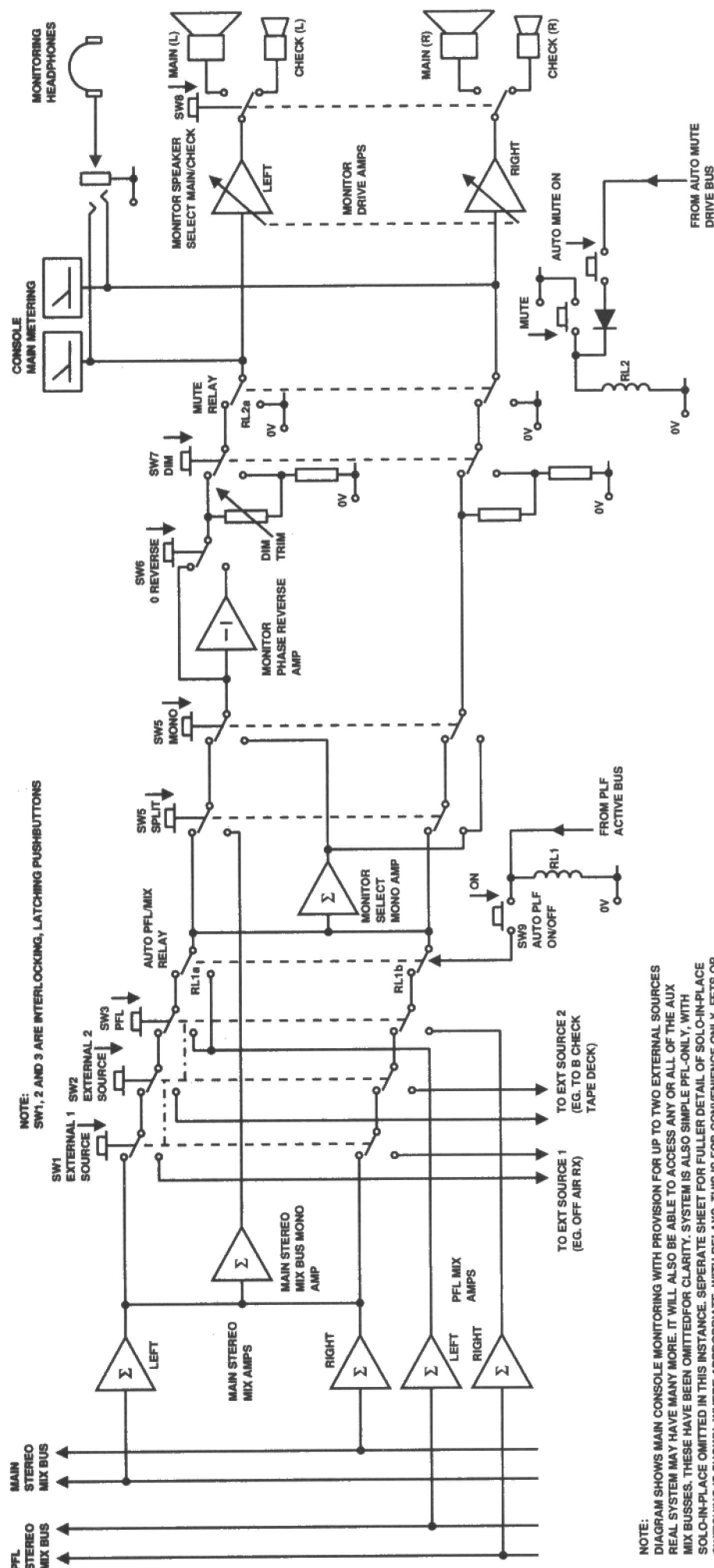OTHER METHODS OF SWITCHING MAY BE ADOPTED IN PRACTICE.

NOTE:
SW1, 2 AND 3 ARE INTERLOCKING, LATCHING PUSHBUTTONS

functions and facilities to be found on desks of all the differing kinds. Some desks have fewer facilities while others have more. The multitrack is a good example, with the master section looking fairly sparse, although the individual components remain very powerful in operation. To illustrate this point, we need only look at the solo system which is a complete entity in itself and, while part of the overall monitoring system architecture, deserves space of its own. A broadcast-style desk, on the other hand, might have a master monitoring section which occupies a very large amount of panel space, perhaps featuring rows and rows of push buttons or rotary switches, so that all inputs can be monitored in isolation.

Monitoring across the width of the console can be lumped broadly into three separate categories. Of these three, two are apparent on the master module - the mainline and auxiliary monitoring functions - while the third is more closely related to the channel monitoring architecture. In essence, mainline relates to monitor source on the main stereo mix bus, solo and PFL while auxiliary monitoring is concerned with FX Sends and Returns and cassette and DAT machine inputs etc.. So-called transient monitoring is found on the channels - we'll look at this type as a separate issue.

You can see in Figure 2 that a series of buttons is provided. These are used to select the input to the main monitor system. Sources available for selection include the multitrack monitor mix, main stereo output, stereo returns from each recorder, disc player, DAT or cassette and there is provision to listen to all echo sends and returns, foldback sends and external signals at the patchbay. After the selector is the most frequently used control, the Master Volume Control. This may be a fader, but is more likely to be a detented rotary pot for an accurate reference for listening. A Dim key is also provided so that listening levels may be brought down by an accurately prescribed amount. This is a useful function to have when one wishes to check balance at a repeatable, lower level, or when using talkback to converse with the artists. This function may also be part of the Rehearsal/Transmission Studio Loudspeaker Silence interlock circuits. Releasing the Dim key restores the

monitor to previous levels. Mute is also provided and operates in conjunction with the SLS/talkback system or when slating to tape.

Mono does as the name suggests and is used to check the mono compatibility of the source being monitored, while phase reverse is also self explanatory and is used to invert momentarily the phase of one speaker, thus allowing a suspected phase error to be verified or otherwise, without resorting to phase reversing the source. Should the engineer be mistaken in this aspect, instigating a phase reversal at this point allows a phase check without any disruption of the main mix.

## Split

Split is used extensively in broadcasting but finds many uses within a recording environment, too. From the diagram, it can be seen that selecting this function routes a mono sum of the main mix bus to one side of the monitoring system loudspeakers and headphones, while allowing another mono sum of whatever source has been selected to the remaining half. It thus allows simultaneous monitoring of two different sources and so the most important monitoring source (the desk output) can always be heard, while keeping track of other sources. Its main use is in network radio where programs and stations may be opting in or out of a large commercial network, inserting their own jingles, adverts etc..

Finally, it is possible to monitor the chosen source on more than one set of speakers (usually two, but sometimes three). This can be done with the large, loud and expensive main monitors, on smaller, high quality 'nearfield' monitors (usually situated on top of the console meter bridge) or on built-in 'check' loudspeakers, sometimes known as idiot speakers. These simulate the effect upon the mix of transistor radios or other low-fi devices.

As already outlined, master module monitoring facilities vary little between the different types of console. The same cannot be said of the channel-by-channel, or transient monitoring facilities. This is because those from the different disciplines place particular emphasis on different requirements and needs from the channel monitoring system.

It is therefore worthwhile outlining the fundamental differences between the various monitoring functions to be found on all types of mixing desks.

## Pre-Fade Level

Pre-Fade Level (usually truncated to PFL), or Cue or Pre-hear as it is sometimes known, is the basic system of monitoring to be found on mixers of all shapes and sizes. As the description suggests, it is a monitoring point originating prior to the channel fader and allows the engineer to verify that the signal is present and at a particular level. It is also useful when checking that the programme is of sufficient quality. PFL monitoring can be done without opening or moving the fader and so recording levels (and the mix) are undisturbed by its operation, that is, it is a non-destructive type of monitoring. The PFL has its own PFL mix bus and the main monitoring loudspeakers (which are normally switched across the main
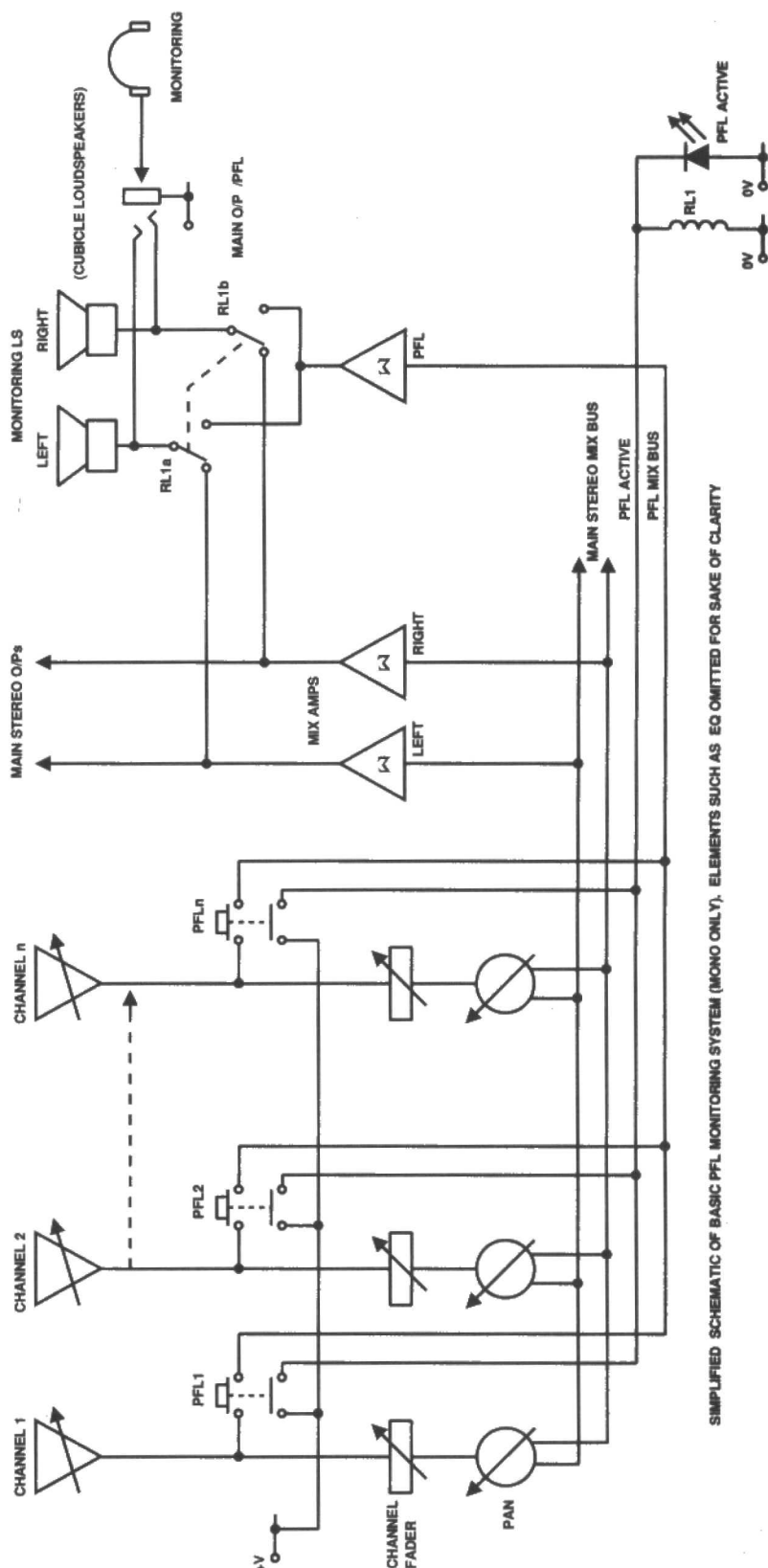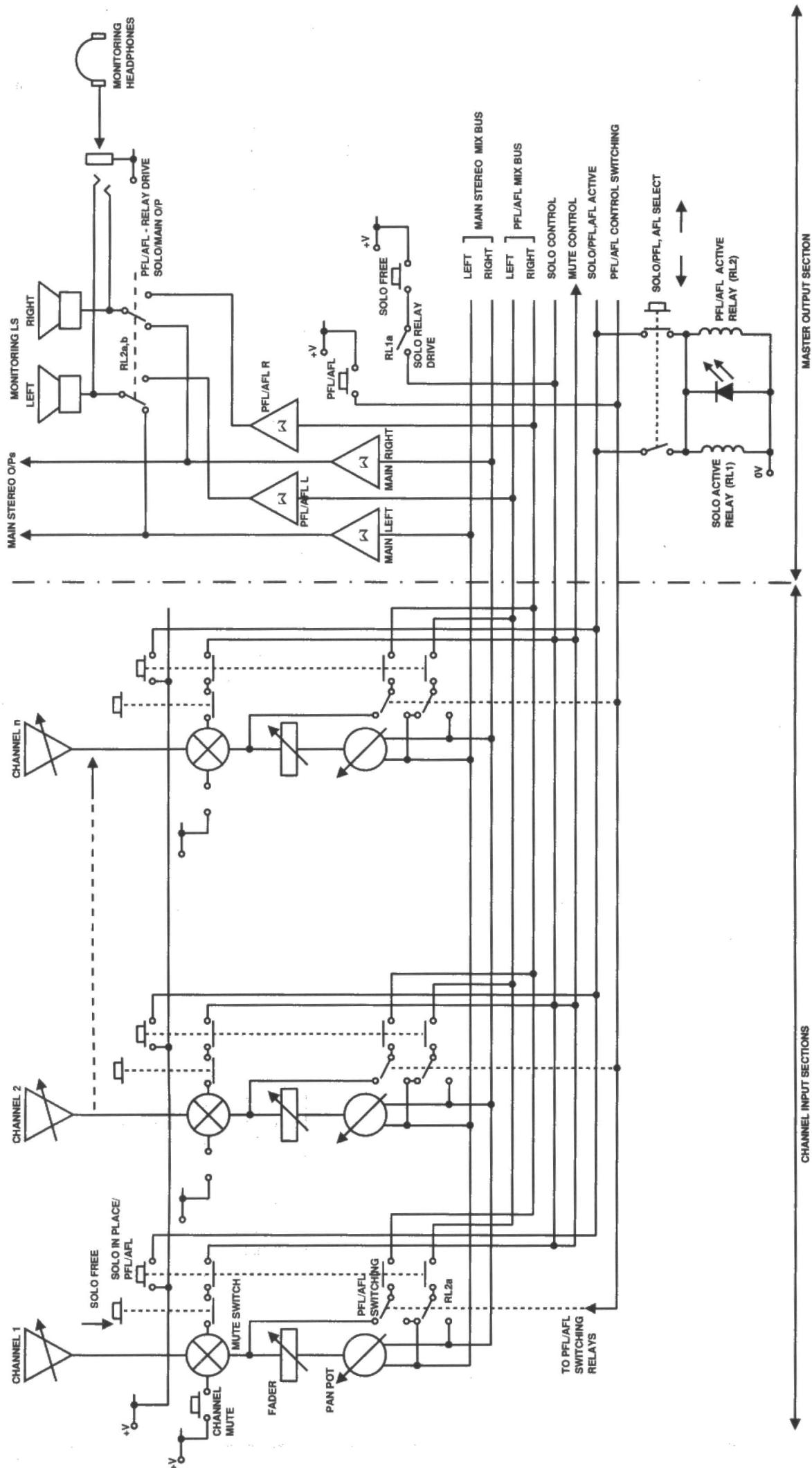


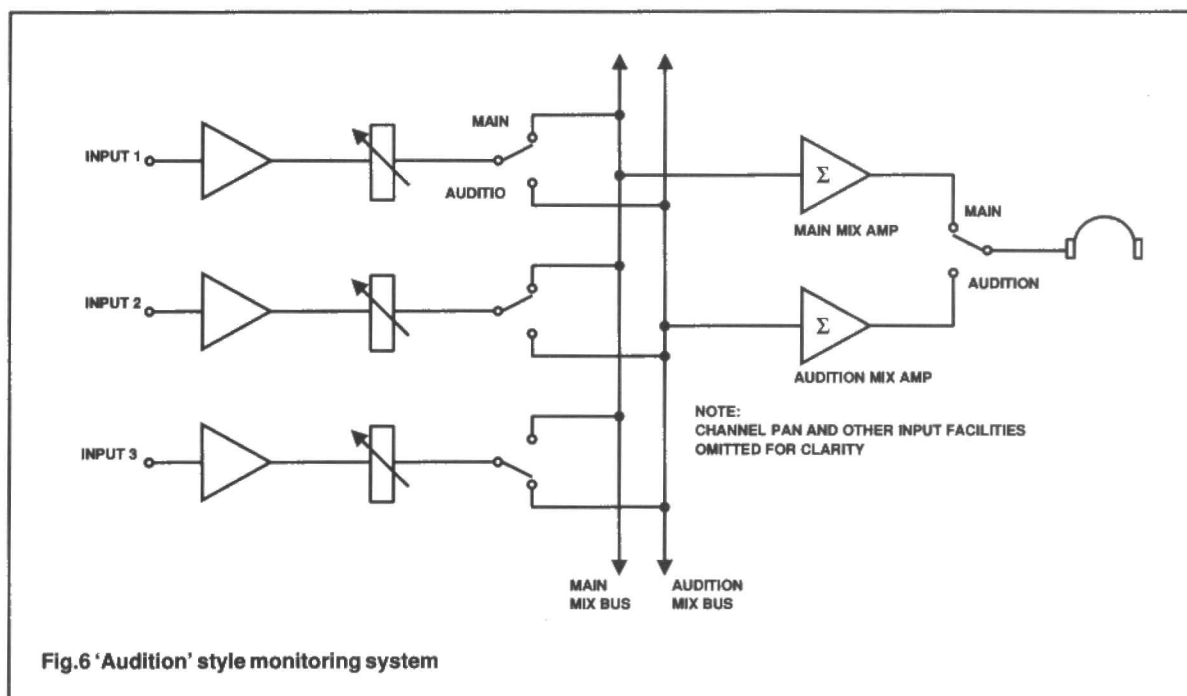Fig.3 Main differences between PFL/AFL and solo monitoring functions. (See also Fig.4)

mix bus) can be arranged to switch to the PFL mix whenever a PFL key is pressed anywhere on the desk. As per Figure 3, selecting PFL anywhere on the desk asserts the PFL Active bus which in turn operates a relay - if Auto PFL Override is selected on the master module - which switches from normal programme (stereo mix) on the monitor loudspeakers to whatever has been PFL'ed. PFL is normally a mono mix, even if there are stereo sources available as input channels.

**SIMPLIFIED SCHEMATIC OF BASIC PFL/AFL MONITORING SYSTEM (MONO ONLY)**
**NOTE: AFL IS POST - FADER BUT PRE - PAN**

**Fig.4**

that the engineer can hear a particular input signal (or number of input signals) both at their proper level and their proper positioning within the stereo field. It is not uncommon for PFL/AFL to be selected globally across the desk from a Master PFL/AFL Select switch located in the master section of the console, although some manufacturers do provide for both on each input module. It is also not unusual to find AFL selection tied in the Solo-in-Place monitoring system, which we shall look at shortly. AFL is known as Solo or Audition in the States, while Solo becomes Solo-in-Place. See Figure 4.

In a recording situation, both PFL and AFL allow the engineer to hear just how much overspill from other, adjacent instruments is entering a particular studio microphone. Unfortunately, neither method allows one to listen to the source in conjunction with any associated FX returns such as echo, reverb etc.. By this time, the engineer will be very well acquainted with how the instrument or vocalist sounds dry (without FX added), since he/she has added an effect to the raw sound in an effort to enhance it in some way. It follows that being able to listen to the sound within the mix, with all of its attendant effects, is now of much greater significance than being able to listen to the sound dry. This is where Solo comes in.

## Solo

On a multitrack desk, this is one of the most important attributes of the whole monitoring system architecture (from an input channel point of view, at any rate). It uses the main stereo mix bus and is used to listen to one or more channels to glean some idea of what the source sounds like in the final mix. It is a very powerful destructive monitoring tool - powerful because it's not just a facsimile of what the channel might sound like in the mix but, in level and spatial positioning, a real representation of it from within, and destructive because it mutes all other channels routed on to the stereo bus. This last statement isn't entirely accurate or true and we'll show why soon, but for now it shows the essence of the system. See Figure 5.

## Audition

This is a slightly uncommon function, found on some broadcast desks in this country, but more common Stateside. It allows the operator to listen to the source on an Audition or Rehearsal bus or on the main bus, but it cannot be switched to both mix busses simultaneously. It is therefore destructive in operation, which can be advantageous, or not in some situations, depending on your point of view. See Figure 6.

## AFL

This is similar to PFL in that it is another non-destructive type of monitoring, taken this time from a point of origin after the fader, as the name suggests. When derived post-panpot - somewhat rare - it will also be a stereo monitoring point, so

Fig 5. Schematic of the true 'Solo-in-Place' monitoring system

SIMPLIFIED SCHEMATIC OF RECORDING DESK-STYLE TRUE 'SOLO-IN-PLACE' (SIP)
MONITORING SYSTEM. SOLO-IN-PLACE IS CORRECT POST PAN, CHANNEL
EXCLUSIVE, STEREO MIX. OTHER CHANNELS CAN BE ISOLATED USING 'SOLO FREE'
PUSHBUTTONS. CONSOLE-WIDE ISOLATION FROM SOLO GAINED BY USING 'MASTER SOLO-FREE'
(LIVE) WHICH FREES CHANNEL MUTING SYSTEM - MONITORING IS PRE-FADE LEVEL (OR POST-FADE
LEVEL) DEPENDING UPON SETTING OF PFL/AFL PUSHBUTTON.

NOTE: INTRICACIES OF SOLO/MUTING CONTROL SYSTEM, AUXILIARY MONITORING AND FINER
DETAILS OF CHANNEL GAIN CONTROL, ROUTING ETC OMITTED FOR CLARITY(SEE SEPARATE
DIAGRAMS FOR FULLER REPRESENTATION OF SALIENT FEATURES OF THESE SECTIONS).

Fig.6 'Audition' style monitoring system

## Upfront

This is a unique form, proprietary to Focusrite and found on their prestigious Studio console. It's a hybrid mix of Solo and AFL, allowing a dimmed mix of one to be superimposed on the other. It allows a balance-pot controlled mix of the AFL signal and that of the mix currently being worked upon. This allows one to hear the soloed signal at full level with an adjustable dimmed mix in the background, allowing EQ and other adjustments to be made in the context of the mix.

## What About Duets when in Solo?

Echo Send is derived from a Post Fade Mix. The processed signal returns to the desk via the FX Return input(s) which will be subjected to their own level, pan and monitoring controls before being mixed onto the main stereo bus.

Taking the common example of a vocalist with a wee bit of reverb added, it is obvious, as already discussed, that when the engineer wishes to solo the vocalist as the mix progresses, he/she will almost certainly want to listen to what the vocalist sounds like in the mix, with the reverb added. If pressing a solo button on that particular channel effects a unilateral muting of all other channels across the width of the desk, the solo monitoring of the vocalist with reverb, FX, etc. added would be impossible to realise.

## Free Solo or Solo Free

No, not a cry for help from the men from U.N.C.L.E.! The operational inconvenience described above is avoided by including a Solo Free (or Solo Kill or Defeat) function in each channel equipped with solo facilities. Invoking the Solo Free function releases that channel from the console-wide solo muting system, thus allowing a collage of different sounds and their attendant effects to be heard in their proper perspective within the stereo mix. Should one press Solo on a Solo Free channel, it is normal for AFL to replace the Solo/Mute action on the rest of the desk - again, this isn't a hard and fast feature and varies from desk to desk. As a consequence of the somewhat disruptive nature of the Solo/Mute function - it could destroy a whole mix if used inadvertently during a live broadcast or recording session, for example - provision is usually made on the master module for a console-wide solo safe function. This inhibits the console channel muting system, converting the solo monitoring facility to an AFL one instead. Again, see Figure 6.

Next month, we finish our look at switching by discussing the routing requirements of a small or medium-sized console.
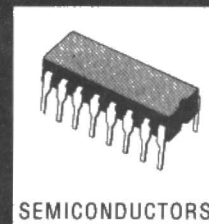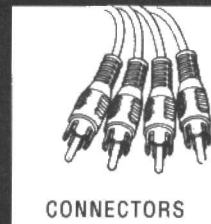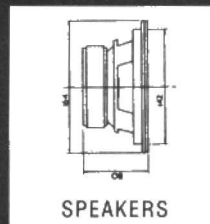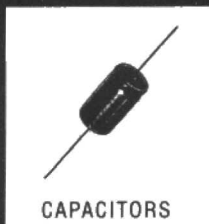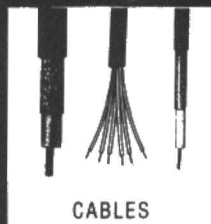
# Charge Pump Devices in Power Supply Design

## by Douglas Clarkson

The starting point in designing any battery operated piece of equipment will probably be deciding which power lines are required and how they should be implemented. If, for example, a 9V battery such as the PP3 is used, then it is simple to produce a single positive regulated line. The 5V line is probably the most commonly used, although often, a -5V line is required, or it may be necessary to have other values in addition.

There are two general solutions to this problem - either use DC to DC converters, or charge pump devices, which in some cases can be implemented as single chips.

One of the key features of battery equipment, however, is the requirement for low battery consumption. In many cases the power requirements for a non-standard rail are quite modest - perhaps 2mA at -12V and 0.5mA at +12V. The efficiency of DC to DC converters at this power loading is typically poor, perhaps as low as 30%, so while they can provide a higher power line, this is done quite inefficiently.

Taking as an example the case where 2mA is provided on the +12 line and -12 line at 30% efficiency from a 5V supply line, the total energy delivered is 48mW, which requires 160mW to be supplied from the +5V line. This equates to 32mA. A 100% efficient converter would only require about 12mA.

## Dual Charge Pump Converter Chips

The MAX680 and MAX681 monolithic dual charge pump converters provide typically ± 10V from a +5 output and can provide a convenient way of producing power supply lines without DC to DC converters. There are, however, as with most devices, limitations on their use which should be recognised. They are relatively new and will take time to be assessed by the electronics industry.

Figure 1 shows the circuit configurations of the two converters. The MAX681 is a 14 pin device which requires no additional circuit components. Pump and reservoir capacitors of value 1μ are fabricated in the chip. The MAX680 is

**Fig.1 Pin layout of the MAX680 and MAX681 devices.**

**Fig. 1b Circuit conficuration of MAX680/ MAX681**
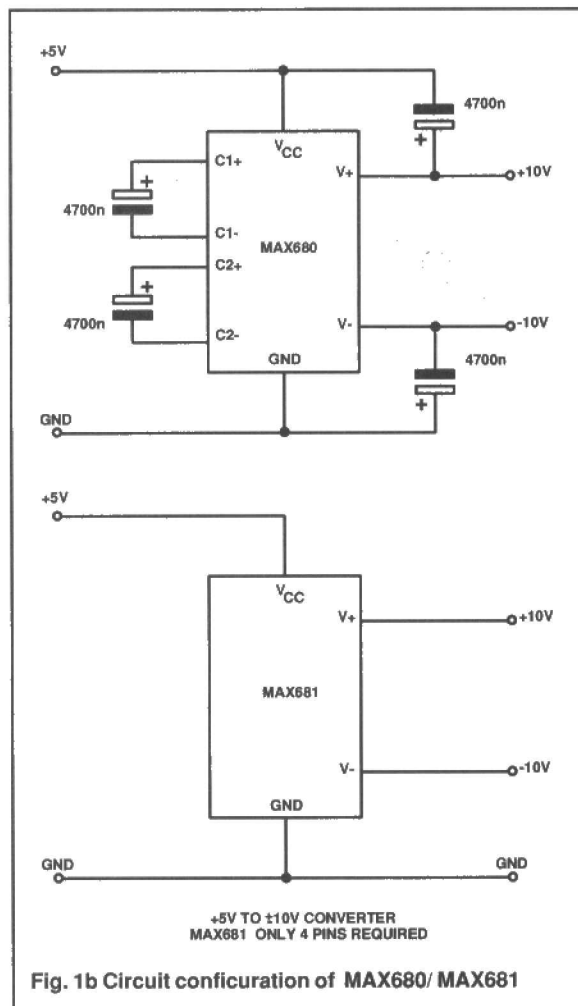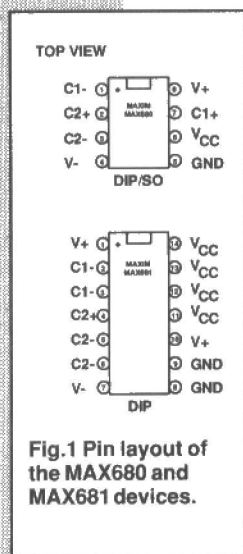
an 8-pin device to which external pump and reservoir capacitors are connected. This may increase the complexity of use of the device but it provides a better drive capability as shown in Figure 2. This is especially true for the negative rail.

In terms of operating points, typically less than 10mA should be supplied to the converted rails. Figure 3 shows how two chips can be connected in parallel to provide greater output current. Additional pump capacitors are needed but the reservoir capacitors can be shared.

The devices are quoted for performance at an input voltage of 5V which is doubled to ±10V. The chips will function up to a maximum input voltage of 6.2V.

As indicated in Figure 2, the output voltage is not regulated and changes significantly with load current. Depending on

**Fig.2 Output drive voltage as a function of total current from V+ to V- for the MAX680 and MAX681.**

the circuit requirements, variable positive and negative voltage regulators can be used to stabilise output. Factors such as the 'headroom' voltage of the regulator and quiescent current of the regulator and the load current on the regulated rail determine whether this process is practicable or not.
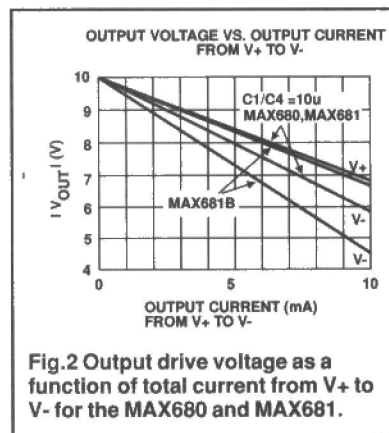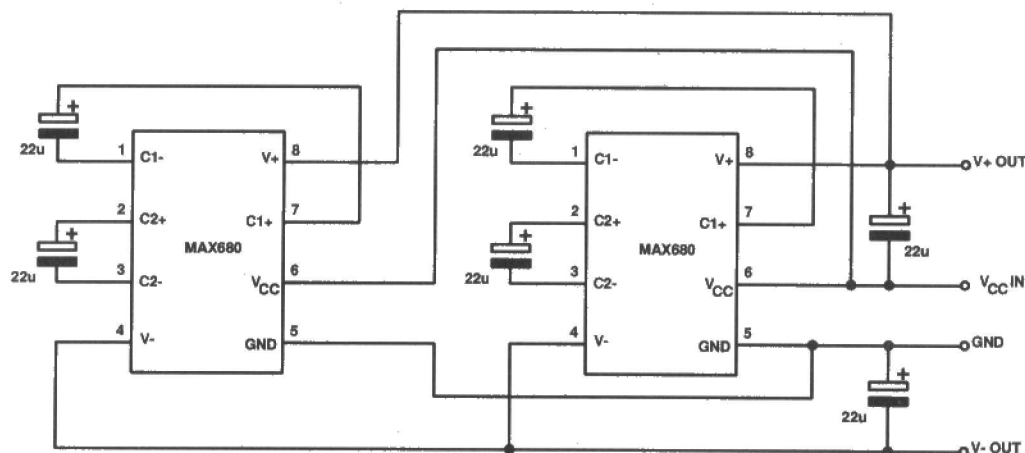
Fig.3 Connection of two chips in parallel to achieve greater output drive current.

Figure 4 shows how the outputs of the MAX680 can be regulated to produce ±5 rails from an input voltage of between 6V and 3V. In the case of a 5V input supply, if a total of 20mA is drawn from the MAX680 and assuming the source resistance of the MAX680 is 150R, then the positive charge pump will drop 3V, leaving 7V for the negative charge pump. A further 1.5V drop due to 10mA load will drop the output negative voltage to -5.5V, enabling the MAX664 to maintain regulation at 5V. Clearly, if additional current was required, regulation would begin to fail first on the negative rail. The efficiency, however, of the charge pump device is high - at least 80%.

In such circuits it is desirable to minimise the combined quiescent current of the chips used. In the example outlined in Figure 4, the quiescent current is less than 0.5mA. Such circuits need to be used carefully in situations where the current taken by the system will not overload the supply regulation system.

There may be situations where voltages other than ±5V are required. Adjustable positive and negative voltage regulators, however, tend to have a high 'headroom' voltage of around 1.5V compared with the 0.5V level of 5V devices, which reduces the drive currents that they can provide. One option may be to use a pair of MAX680s to increase current drive ability as outlined in Figure 3.

The 3 terminal positive adjustable regulator TL317M shown in Figure 5 can be used to vary the positive output voltage as required. The LM237 and LM337 regulators can be used to regulate the negative output rail.

## High-Side Power Supplies

There are numerous requirements in a circuit for 'high' voltage lines which consume little current. One example is that of analogue switches or analogue multiplexers, where a +12V line may be required. The MAX622/MAX623 devices operate by implementing a regulated series charge pump to
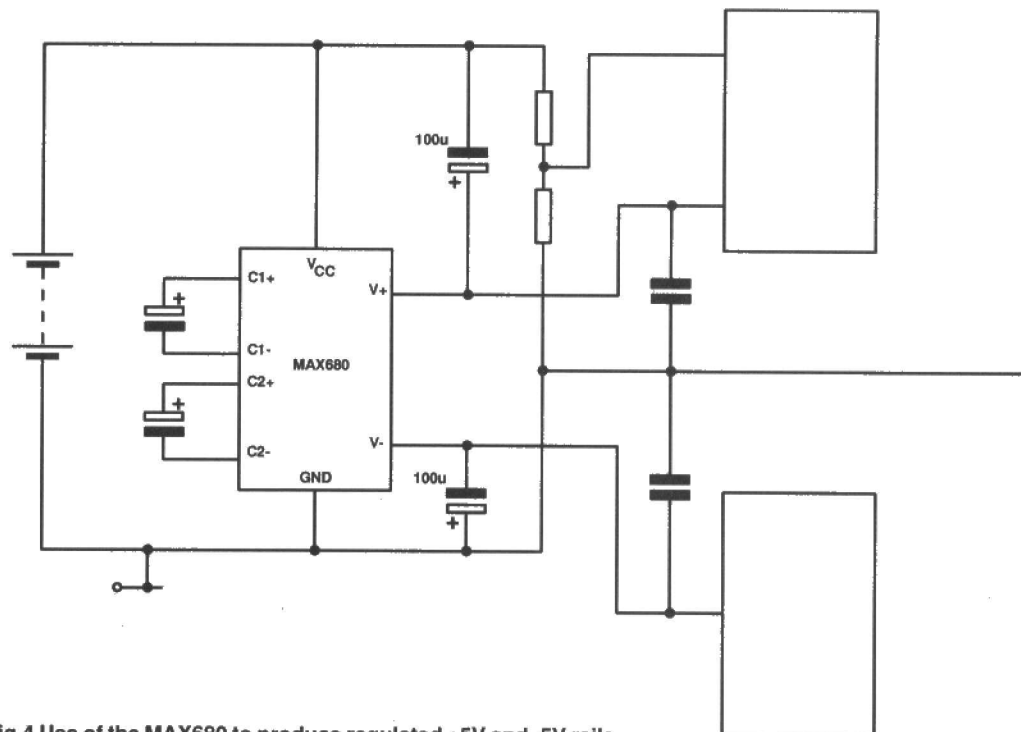


Fig.4 Use of the MAX680 to produce regulated +5V and -5V rails from a single supply input.

produce an output voltage 11V higher than the input voltage, assuming this value is maintained in the range 3.5V to 16.5V. The chip can therefore provide a maximum output voltage of 27.5V.
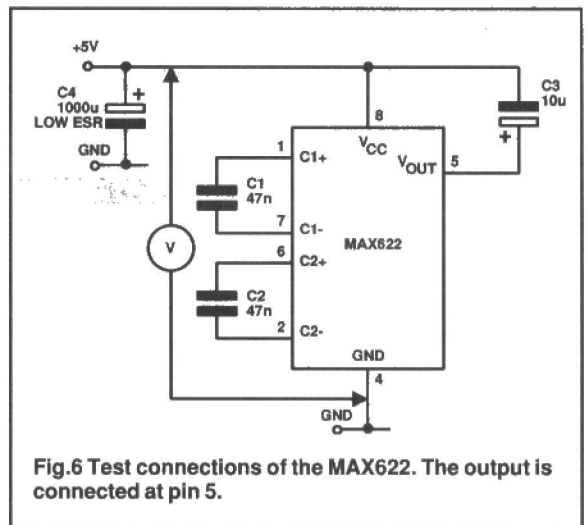
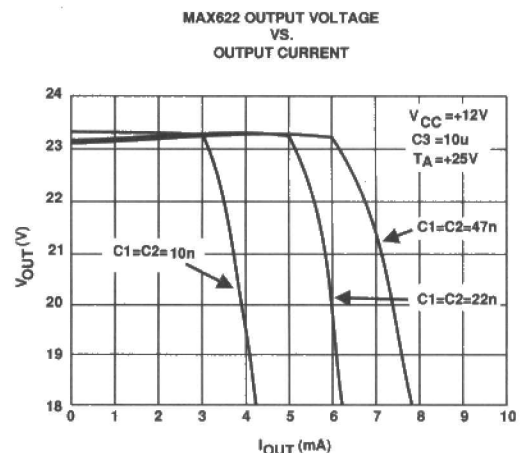Figure 6 shows the test connections of the MAX622 with output at pin 5. Figure 7 shows the variation in output drive of the MAX622 as a function of different values of pump and reservoir capacitors. Thus, a typical configuration can output
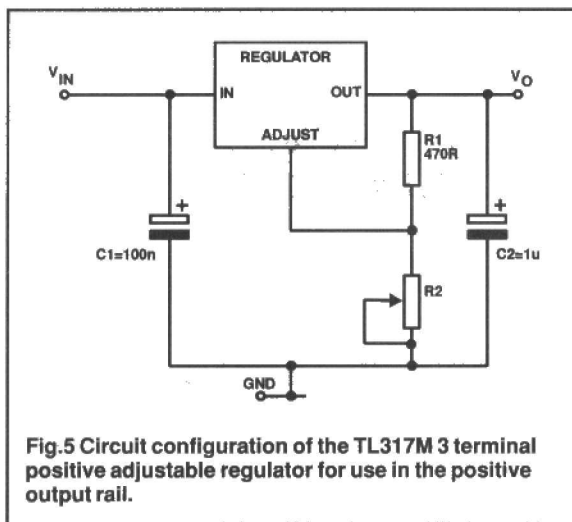
**Fig.5 Circuit configuration of the TL317M 3 terminal positive adjustable regulator for use in the positive output rail.**



**Fig.6 Test connections of the MAX622. The output is connected at pin 5.**

around 23V at 5mA from an input voltage of 12V. The level of output drive is considerably reduced for a supply voltage of 5V. Typically, less than 1mA can be obtained at an output voltage of 16V. The MAX622 and MAX623 devices do provide flexibility for the circuit designer where high voltage lines with low current drive capabilities are required.

## Voltage Converter MAX660

In many applications this is already an 'old faithful'. It can be used in two main modes - voltage inversion and voltage doubling based on an input voltage range between 1.5V and 5.5V. The chip is better placed to drive higher loads. Its typical output impedance of 6.5R is quite modest compared to that of the MAX680/681 allowing the device to deliver 100mA at 9.5V from a +5 supply. The MAX660 is a pin compatible high current upgrade of the ICL7660.

Figure 8 shows how the device can be configured for voltage doubling and voltage inversion. The device has a low 0.2mA operating current and an efficiency around 95%.



**Fig.7 Variation in output drive of the MAX622 as a function of different values of pump and reservoir capacitors.**

The devices can be configured in parallel to reduce output resistance and also cascaded to increase output voltage produced by negative multiplication.

## Conclusion

Charge pump devices such as the MAX680/681 and the MAX622/623 can often be used to provide higher supply lines from a lower value one where previously this would have required DC to DC converters or more expensive power supplies. The use of such charge pump devices can often lead to disappointment in situations where the current drive requirements have been underestimated.

Such charge pump devices can probably be used to best advantage in battery operated equipment where DC to DC converters are inefficient at low output current levels. The tidiest use of such circuits is where the outputs can be regulated and where the current demand will maintain regulation at all levels of circuit configuration. Where currents in excess of 10 to 15mA are required, then conventional DC to DC converters are probably the solution.

The circuit designer needs to keep an eye on the range of such chips available - the rapid increase in low power battery operated equipment is creating a ready market for such basic circuit design elements.



**Fig.8 Typical configurations of the MAX660 voltage converter - voltage inversion and voltage doubling.**

# ETI ELECTRONICS TODAY INTERNATIONAL

# PCB Service July

| Price code | Price (inc. VAT) |
|---|---|
| C | £1.80 |
| D | £2.50 |
| E | £3.25 |
| F | £4.00 |
| G | £4.75 |
| H | £5.50 |
| J | £6.62 |
| K | £7.20 |
| L | £8.80 |
| M | £10.60 |
| N | £13.10 |
| O | £15.80 |
| P | £17.90 |
| Q | £21.80 |
| R | £23.90 |
| S | £25.90 |
| T | £29.00 |
| U | £32.20 |
| V | £35.80 |
| W | £37.90 |
| X | £40.70 |

| E9307-1 | Car Battery Tester (Double Sided - Surface Mount) | E |
|---|---|---|
| E9307-2 | Mind Trainer | F |
| E9307-FC | Microwave Monitor | F |

PCBs for the remaining projects are available from the companies listed in Buylines.

Use the form or a photocopy for your order. Please fill out all parts of the form. Make sure you use the board reference numbers. This not only identifies the board but also tells you when the project was published. The first two numbers are the year, the next two are the month.

Terms are strictly payment with order. We cannot accept official orders but we can supply a proforma invoice if required. Such orders will not be processed until payment is received.

## ETI PCB Service, Reader's Services, Argus House, Boundary Way, Hemel Hempstead HP2 7ST

**Please Supply:**

| Quantity | Ref No. | Price Code | Price | Total Price |
|---|---|---|---|---|
| | E | | £ | £ |
| | E | | £ | £ |
| | E | | £ | £ |
| | | | Post & Packing | £ 0.75 |
| | | | Total Enclosed | £ |

Please send my PCBs to:

Name ...........................................................

Address .......................................................

.....................................................................
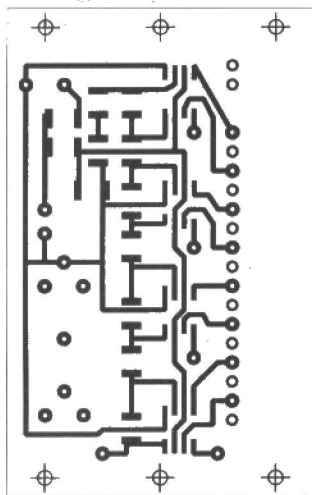
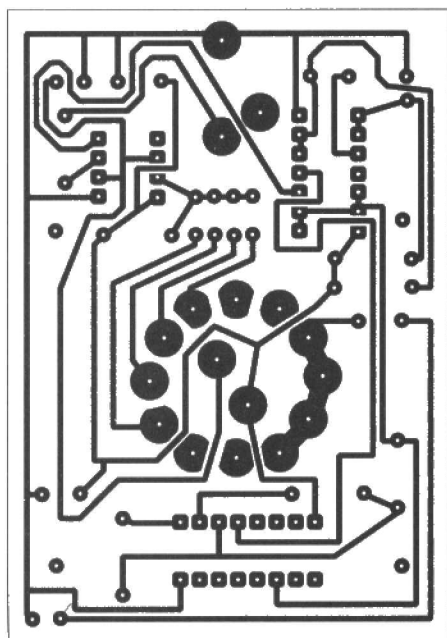.................................... Postcode .................

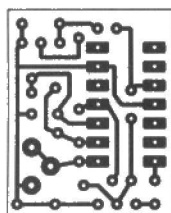## CHEQUES SHOULD BE MADE PAYABLE TO ASP Ltd.

# PCB Foils

The PCB foil patterns presented here are intended as a guide only. They can be used as a template when using tape and transfer for the creation of a foil.
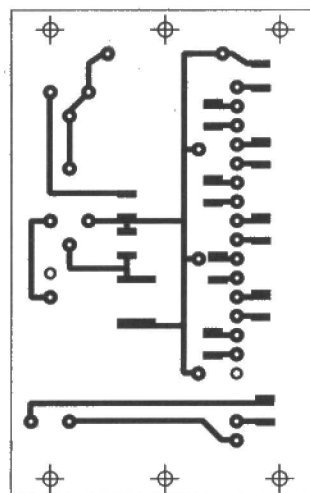
**Car Battery Tester
Bottom Side (a few components)**
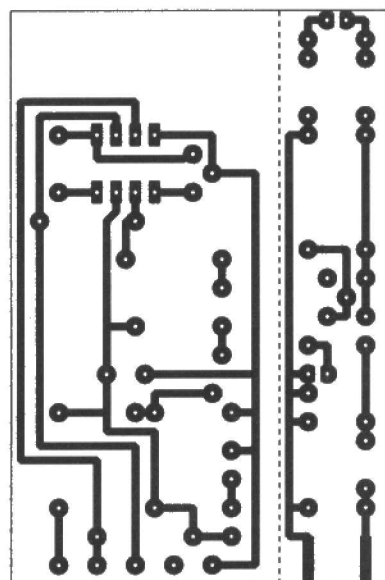
**Car Battery Tester
Main Component Side**

**Microwave Monitor**

**The Mind Trainer**

**Switch Change for Radio Control**

**Low Power Speed Controller June '93**

Most of the capacitor numbering is incorrect owing to a renumbering on the circuit diagram without ammendment to the parts list. Capacitor values are as follows:

C1     1μ/10V
C2     2μ2/10V
C3     33n ceramic
C4,5   100n ceramic
C6     10μ/10V

# SERIOUS SOUND
# SERIOUS SAVING

## HIGH QUALITY PROFESSIONAL 100W POWER AMPLIFIER KIT – SAVE £30

★ **Ideal for Instrument Amplification**   ★ **Stage Foldback**   ★ **Small Venue P.A.**   ★ **Studio Monitor Amplifier**



1992/3 Catalogue Price **£159·95**
### NOW ONLY [H]
# £129.95
**Order Code LT11M**

This superb amplifier kit brings together five of the best and most popular 'Audio Building Blocks', to produce an amplifier of unrivalled sound quality at the price. The Power Output Stage is an excellent 150W MOSFET design which is currently Maplin's Best Selling Audio Kit. It is complemented by the excellent performance of the SSM2016 Differential Preamplifier which has also featured in Maplin's 'Top 20' kits. The superb audio stages are supported by a High Quality Power Supply Unit, sophisticated Monitoring Circuitry and a Thermal Protection System. Housed in a rugged 19in. rack mounting case, this outstanding amplifier is designed for longevity, purity of sound reproduction and ease of integration with other professional equipment.

The kit contains everything you need to build this superb amplifier and is supplied complete with comprehensive constructional information.

## Features:
★ **Standard 19in. 2U Rack Mounting Case**
★ **100W RMS Power Output**
★ **Balanced Line Input**
★ **Loudspeaker Protection**
★ **Switch-on Mute**
★ **Thermal Protection**

**Typical Specification:**
Rated Load Impedance: 4 to 8Ω
Maximum Power Output:

| | |
|---|---|
| 4Ω | 105W RMS |
| 8Ω | 90W RMS |

THD @ 75W (1kH⁻
Frequency Respo

**M**

## CREDIT C RD HOTLINE
# 0702 554161
**Mail Order to: P.O. Box 3, Rayleigh, Essex SS6 8LR**